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2.	Patent application number *(The Patent Office will fill in this part)*	-3 APR 1998
3.	Full name, address and postcode of each applicant *(underline all surnames)* 9807102.0	Schlumberger Holdings Limited PO Box 71 Craigmuir Chambers Road Town Tortola British Virgin Islands
	Patents ADP number *(if you know it)*	7236326001
	If the applicant is a corporate body, give the country/state of its incorporation	British Virgin Islands
4.	Title of the invention	SIMULATED SYSTEM INCLUDING A CASE MANAGER ADAPTED FOR ORANIZING AND MANAGING SETS OF INPUT DATA USED BY THE SIMULATION SYSTEM
5.	Name of your agent *(if you have one)*	B D Stoole
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Geco-Prakla Technical Services Inc Schlumberger House Buckingham Gate Gatwick West Sussex RH6 0NZ
	Patents ADP number *(if you know it)*	7086721001

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SIMULATION SYSTEM INCLUDING A CASE MANAGER ADAPTED FOR ORGANIZING AND MANAGING SETS OF INPUT DATA USED BY THE SIMULATION SYSTEM

BACKGROUND OF THE INVENTION

The subject matter of the present invention relates to a reservoir simulator apparatus and associated method responsive to a set of data for simulating an earth formation located in the vicinity of an oilfield reservoir and for displaying a set of simulation results in response to the simulation, and, more particularly, to a system including a case manager apparatus adapted for organizing and managing the data used by the reservoir simulator, the simulator generating a set of simulation results and displaying the simulation results in response to the data.

Reservoir modeling is performed in order to predict the degree of underground deposits of hydrocarbon bearing formations in an earth formation. Typically, well logging operations are performed in the formation thereby producing well log data, and seismic operations are performed on the formation thereby producing seismic data. The seismic data is reduced thereby producing reduced seismic data. The well log data and the reduced seismic data are introduced, as input data, to a computer workstation which stores a gridding software and a simulator software. A gridding software, hereinafter known as "the Flogrid software" or the "Flogrid gridding software", is disclosed in prior pending Great Britain patent application number 9727288.4 filed December 24, 1997, the disclosure of which is incorporated by reference into this specification. The "Flogrid" gridding software includes another gridding software known as "Petragrid". The "Petragrid" gridding software is disclosed in

prior pending U.S. patent application serial number 08/873,234 filed June 11, 1997, the disclosure of which is incorporated by reference into this specification. The gridding software will respond to the reduced seismic data and the well log data by gridding the earth formation which was subjected to the well log operation and the seismic operation. The type of grids imposed on the earth formation include structured (approximately rectangular) grids and unstructured (tetrahedral) grids. A property, such as permeability or water saturation, is assigned to each cell or grid block of the grid. As a result, a set of output data is generated by the gridding software, the set of output data including the plurality of cells/grid blocks of the grid and the respective plurality of properties associated with each of the cells of the grid. The set of output data are introduced, as input data, to the reservoir simulator software. The reservoir simulator software will respond to the set of output data from the gridding software by generating a plurality of simulation results which are associated, respectively, with the plurality of cells/grid blocks of the grid received from the gridding software. The plurality of simulation results and the plurality of cells/grid blocks associated therewith, generated by the reservoir simulator software, will be displayed on a 3D viewer of the workstation for observation by a workstation operator. Alternatively, the plurality of simulation results and the plurality of cells/grid blocks associated therewith can be recorded for observation by a workstation recorder.

The reservoir simulator software can model an oilfield reservoir. For example, in the Society of Petroleum Engineers (SPE) publication number 28545, concerning a transient tool for multiphase pipeline and well simulation, dated 1994, the authors have solved for pressure losses along a single pipeline using a technique related to conservation of material and conservation of pressure. A similar technique has been applied to a network of pipelines or flowlines in the Society of Petroleum Engineers (SPE) publication number 29125, authored by Litvak and Darlow. In this publication, the authors (Litvak and Darlow) have taken a network model (i.e., a network of pipelines) in which the pressure losses along the network branches can either be calculated from tables or from an analytical model, and the analytical model solves for three (3) conservations

and pressures. In addition, in an article by the "Society of Petroleum Engineers" (SPE) 12259, each well being modeled in that article was characterized by three (3) variables: pressure, water fraction, and gas fraction.

As noted above, the set of output data from the gridding software (including the plurality of cells/grid blocks of the grid and the respective plurality of properties associated with each of the cells of the grid) are introduced, as input data, to the reservoir simulator software, and, responsive thereto, the reservoir simulator will generate a first set of simulation results which will be displayed for viewing by an operator. Another set of input data will subsequently be input to the reservoir simulator, and a second set of simulation results will be displayed for viewing by the operator. Still another set of input data will subsequently be input to the reservoir simulator, and a third set of simulation results will be displayed for viewing by the operator.

However, advances in technology over the last few years have meant that today's reservoir engineer is faced with managing more data and making better informed decisions in a shorter time than ever before. Technology has enabled more data to be incorporated, more complex models to be built, and more realizations to be studied. As a result, more data must be managed, more models must be created, and more results must be analyzed. Consequently, a reservoir engineer must continuously remember and keep track of a multitude of sets of input data which are being input to a reservoir simulator.

Therefore, some type of method and apparatus for automatically organizing and managing the input data (which are being input to the reservoir simulator) is necessary, and that apparatus would allow the reservoir engineer to efficiently manage the input data while creating new models and analyzing the results generated from those models.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a new and novel method and apparatus, hereinafter called a "case manager", for automatically organizing and managing a plurality of sets of input data which are being provided to a reservoir simulator in order to allow a reservoir engineer to efficiently organize and manage that input data while creating new models and analyzing a plurality of sets of results generated from those new models.

In accordance with the above referenced object, it is a primary aspect of the present invention to provide a simulation system and associated method, which is responsive to a plurality of sets of input data, for simulating an earth formation located in the vicinity of an oilfield reservoir, generating a set of simulation results in response to the simulation, and displaying the set of simulation results, the simulation system including a case manager adapted for organizing and managing the plurality of sets of input data being used by the simulation system.

It is a further aspect of the present invention to provide the above referenced simulation system, wherein the case manager includes a plurality of case scenarios organized in a tree-like structure, some case scenarios being subsets of other case scenarios in the tree-like structure, an operator selecting one or more of the case scenarios in the case manager.

It is a further aspect of the present invention to provide the above referenced simulation system, wherein the simulation system further includes a case builder adapted for receiving the one or more of the case scenarios selected by the operator, editing and/or changing a set of data disposed within the selected case scenarios in response to editing actions taken by the operator, and, responsive thereto, for generating a set of edited case scenarios.

It is a further aspect of the present invention to provide the above referenced simulation system, wherein the simulation system further includes a simulator adapted to be executed, and a run manager responding to the set of edited case scenarios from the case builder by submitting the edited case scenarios to the

simulator, the simulator responding to the edited case scenarios from the run manager by executing and thereby generating a set of simulation results, the set of simulation results from the simulator being stored in a results file, the run manager receiving the set of simulation results from the results file in addition to the set of edited case scenarios from the case builder thereby enabling an operator to monitor and compare via the run manager the set of simulation results received from the results file with the set of edited case scenarios received from the case builder, and, responsive thereto, to select one or more additional case scenarios via the case manager.

It is a further aspect of the present invention to provide the above referenced simulation system, wherein the simulation system responds to the set of simulation results generated by the simulator by displaying or reporting those simulation results, the simulation system including a results viewer for displaying the set of simulation results generated by the simulator and a report generator for generating one or more reports which record the set of simulation results, the results viewer displaying not only the set of simulation results but also any instantaneous changes being made to the set of simulation results at any point in time.

In accordance with these and other aspects of the present invention, a "simulation system" includes a workstation and a simulator (called "Eclipse") which is a software package that is adapted to be stored in a memory of the workstation. The "Eclipse" simulator is originally stored on a CD-Rom, the simulator being subsequently loaded from the CD-Rom and stored in the memory of the workstation. The simulator will respond to certain "input data" during the pendency of its execution, and a resultant set of simulation results will be displayed on a 3D viewer.

In a prior pending application, a gridding software, known as "Flogrid", generated a set of output data, the set of output data including a plurality of cells/grid blocks of a grid and a respective plurality of properties associated with each of the cells of the grid. The set of output data from "Flogrid" are

introduced, as the "input data", to the simulator. The simulator responds to that "input data" by generating a plurality of simulation results which are associated, respectively, with the plurality of cells/grid blocks of the grid received from the "Flogrid" gridding software. The plurality of simulation results and the plurality of cells/grid blocks associated respectively therewith, generated by the simulator, are displayed on a 3D viewer of a workstation for observation by a workstation operator. The prior pending application is Great Britain patent application number 9727288.4 filed December 24, 1997, the disclosure of which has already been incorporated by reference into this specification.

However, in addition to the "Eclipse" simulator, the "simulation system" further includes a "display means" operatively connected to the simulator for displaying or reporting the set of simulation results generated by the simulator and an "organizing and managing system" (known as "Eclipse Office"), in accordance with the present invention, operatively connected to the simulator for organizing and managing the "input data" that is input to the simulator and for enabling a comparison of the set of simulation results generated by the simulator with other types of the "input data". The Eclipse Office "organizing and managing system", in accordance with the present invention, further includes the following components: a case/project manager in accordance with one aspect of the present invention for organizing and managing a set of input data adapted to be introduced as input data to the simulator, a case builder/data manager, and a run manager. The "display means" further includes the following components: a results viewer, and a report generator.

In operation, the case/project manager of the simulation system in accordance with one aspect of the present invention stores a plurality of different scenarios of test "input data" in a tree-like structure. As a result of the tree-like structure, the case/project manager will neatly organize and manage, for the operator, the test input data thereby enabling an operator of the workstation to select one or more sets of the test input data in the tree like structure for introduction to the simulator. When the operator selects one or more of the

test input data in the tree like structure of the case/project manager, that input data is temporarily stored in the case builder/data manager. The operator can now edit the test input data temporarily stored in the case builder/data manager, as desired. Alternatively, other input data from other "pre-processor" programs can be temporarily stored in the case builder/data manager and can be edited by the operator. Alternatively, other "raw data" (from the "Flogrid" gridding program mentioned above) can be temporarily stored in the case builder/data manager and edited by the operator. When the "input data" in the case builder/data manager has been edited as desired, that "edited input data" is sent to the run manager, the run manager submitting that "edited input data" to the simulator. A processor of the workstation will execute the simulator software and, during that execution, the processor will simultaneously use the "edited input data" supplied by the run manager. When the execution of the simulator software is complete, a set of simulation results will be generated by the simulator. That set of simulation results will be stored in a results file of the simulation system. That set of simulation results in the results file will be transmitted back to the run manager thereby allowing the run manager to monitor and compare (for the workstation operator) that set of simulation results from the results file with the "edited input data" supplied to the run manager by the case builder/data manager. Based on that comparison, the operator at the workstation can then select other test input data stored in the tree like structure of the case/project manager and run that other test input data through the simulator in order to view other sets of simulation results. In addition, that set of simulation results from the results file will also be sent to a results viewer for display on a 3D viewer, and, in addition, that set of simulation results from the results file will also be sent to a report generator for recording that set of simulation results in the form of a written report that can be provided to the operator.

Further scope of applicability of the present invention will become apparent from the detailed description presented hereinafter. It should be understood, however, that the detailed description and the specific examples, while representing a preferred embodiment of the present invention, are given by way

of illustration only, since various changes and modifications within the spirit and scope of the invention will become obvious to one skilled in the art from a reading of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the present invention will be obtained from the detailed description of the preferred embodiment presented hereinbelow, and the accompanying drawings, which are given by way of illustration only and are not intended to be limitative of the present invention, and wherein:

figures 1 and 2 illustrate a seismic operation for producing a reduced seismic data output record, the seismic operation of figure 1 including a data reduction operation;

figures 3, 4a, and 4b illustrate a more detailed construction of the data reduction operation of figure 1;

figure 5 illustrates a wellbore operation for producing a well log output record;

figures 6 and 7 illustrate a workstation adapted for storing a "Flogrid" software and an "Eclipse" simulator software;

figure 8 illustrates a more detailed construction of the "Flogrid" software of figure 7;

figure 9 illustrates an example of a typical output display generated by the "Eclipse" simulator software of figure 8 and produced on the 3D viewer of figure 8 ;

figure 9a illustrates the workstation of figures 6, and 7, however, the workstation of figure 9a stores the Flogrid software, the Eclipse simulator software, and the Eclipse Office software in accordance with the present

invention, the software being loaded into the workstation from a CD-Rom storage device;

figure 10 illustrates a more detailed construction of the Eclipse simulator software and the manner by which the Eclipse Office software interfaces with the Eclipse simulator software for producing a "display or reporting results" in response to a set of data received from pre-processor programs, and in response to certain raw data;

figure 11 illustrates a more detailed construction of the Eclipse Office software of figure 10 of the present invention including the case/project manager in accordance with the present invention, and a more detailed construction of the "display or reporting results" of figure 10;

figure 12 illustrates the output produced by the "case/project manager" of figure 11 in accordance with the present invention, part of the Eclipse Office software of the present invention;

figure 13 illustrates a flowchart or block diagram illustrating a construction of the "case builder/data manager" of figure 11, part of the Eclipse Office software of the present invention;

figure 14 illustrates a flowchart or block diagram illustrating a construction and/or a functional operation of the "run manager" of figure 11, part of the Eclipse Office software of the present invention;

figure 15 illustrates a flowchart or block diagram illustrating a construction and/or a functional operation of the "results files" and the "display or report results" including the "results viewer" and the "report generator" of figure 11;

figure 16 illustrates a workflow or functional block diagram of the operation of the Eclipse Office software of the present invention, of figure 11;

figure 17 illustrates a dialog depicting the Eclipse Office application layout;

figure 18 illustrates a workflow or functional block diagram of the case/project manager of the Eclipse Office software of the present invention;

figure 19 illustrates a dialog depicting the case/project manager layout;

figure 20a illustrates a workflow or functional block diagram of the case builder/data manager of the Eclipse Office software of the present invention;

figure 20b illustrates a continuation of the workflow or functional block diagram of figure 20a of the case builder/data manager of the Eclipse Office software of the present invention;

figure 21 illustrates a dialog depicting the case builder/data manager layout;

figure 22 illustrates a dialog depicting a reservoir description layout;

figure 23 illustrates a dialog depicting a PVT layout;

figure 24 illustrates a dialog depicting a SCAL layout;

figure 25 illustrates a dialog depicting a Schledule layout;

figure 26 illustrates a workflow or functional block diagram of the run manager of the Eclipse office software of the present invention;

figure 27 illustrates a window display generated by the run manager;

figure 28 illustrates a workflow or functional block diagram of the results viewer of figure 11; and

figure 29 illustrates a workflow or functional block diagram of the report generator of figure 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

This specification will be divided into two parts: (1) a first section containing background information leading up to a discussion of the Eclipse Office software of the present invention, and (2) a second section containing a Detailed Description of the Eclipse Office software of the present invention, the second section including a General Discussion of the Eclipse Office software, and a Detailed Discussion of the Eclipse Office software of the present invention.

First Section - Background Information

Referring to figure 1, a method and apparatus for performing a seismic operation is illustrated. During a seismic operation, a source of sound vibrations 10, such as an explosive energy source 10, produces a plurality of sound vibrations. In figure 1, one such sound vibration 12 reflects off a plurality of horizons 14 in an earth formation 16. The sound vibration(s) 12 is (are) received in a plurality of geophone-receivers 18 situated on the earth's surface, and the geophones 18 produce electrical output signals, referred to as "data received" 20 in figure 1, in response to the received sound vibration(s) 12 representative of different parameters (such as amplitude and/or frequency) of the sound vibration(s) 12. The "data received" 20 is provided as "input data" to a computer 22a of a recording truck 22, and, responsive to the "input data", the recording truck computer 22a generates a "seismic data output record" 24. Later in the processing of the seismic data output record 24, such seismic data undergoes "data reduction" 30 in a mainframe computer, and a "reduced seismic data output record" 24a is generated from that data reduction operation 30.

Referring to figure 2, another method and apparatus for performing a seismic operation is illustrated. Figure 2 was taken from a book entitled "Seismic Velocity Analysis and the Convolutional Model", by Enders A. Robinson, the disclosure of which is incorporated by reference into this specification.

In figure 2, the seismic operation of figure 1 is performed 10 different times. For example, when the explosive or acoustic energy source 10 is located at position 26 (the first position or position "0" along the surface of the earth) in figure 2, a first plurality of electrical signals from the geophones 18 are stored in the computer 22a in the recording truck 22. The explosive energy source is moved to position 28. When the explosive energy source 10 is located in position 28 (the second position or position "1" along the surface of the earth), a second plurality of electrical signals are stored in the computer 22a in the recording truck 22. The explosive energy source 10 is repeatedly and sequentially moved from positions "2" to "9" in figure 2 until it is located at position 32 (i.e. - position "9" which is the tenth position) on the surface of the earth. When the explosive energy source 10 is located in position 32 (the tenth position along the surface of the earth), a tenth plurality of electrical signals are stored in the computer 22a in the recording truck 22. As a result, in figure 2, the recording truck 22 of figure 1 records a "set of 3D seismic data" which consists of the 10 traces or ten sets of electrical signals, where each set of electrical signals comprises a plurality of electrical signals that originated from subsurface locations situated between position 26 and position 32 along the surface of the earth. A seismic data output record 24 will be generated by the computer 22a in the recording truck 22 which includes the "set of 3D seismic data" received from the geophones 18. The method and apparatus described above with reference to figures 1 an 2 represent a "3D seismic operation".

Referring to figure 3, the seismic data output record 24 of figure 1 is provided as "input data" to a mainframe computer 30 where the data reduction operation 30 of figure 1 is performed. A mainframe processor 30a will execute a data reduction software 30b stored in a mainframe storage 30b. When the

execution of the data reduction software 30b is complete, the reduced seismic data output record 24a of figures 1 and 3 is generated.

Referring to figures 4a and 4b, a flowchart of the data reduction software 30b stored in the mainframe storage 30b of the mainframe computer 30 of figure 3 is illustrated. The data reduction software flowchart of figures 4a and 4b is taken from a book entitled "Seismic Velocity Analysis and the Convolutional Model" by Enders A. Robinson, the disclosure of which has already been incorporated by reference into this specification.

In figures 4a and 4b, the flowchart of the data reduction software 30b includes the following blocks: a demultiplexing block 30b1 connected to the input, a sorting block 30b2, a gain removal block 30b3, a frequency filtering block 30b4, a resampling block 30b5, a trace selection block 30b6, an output 30b7 labelled "selected gathers (velocity analyses)", amplitude correction 30b8, deconvolution 30b9, a second output 30b10 labelled "CMP sorted traces after deconvolution", a time corrections block 30b11, an AGC block 30b12, a stacking block 30b13, a third output 30b14 labelled "stacked traces (unfiltered)", a frequency filtering block 30b15, another AGC block 30b16, a fourth output 30b17 labelled "stacked traces (filtered)", a second input labelled "dip information" 30b18, a trace interpolation block 30b19, a migration block 30b20, a fifth output 30b21 labelled "migrated traces (unfiltered)", a frequency filtering block 30b22, an AGC block 30b23, a sixth output 30b24 labelled "migrated traces (filtered)", a time to depth correction block 30b25, and a seventh output 30b26 labelled "migrated traces (depth migrated)". In the flowchart of figures 4a and 4b, any of the outputs 30b7, 30b10, 30b14, 30b17, 30b21, 30b24, and 30b26 can be used as the "reduced seismic data output record" 24a which is being provided as input data to the workstation discussed below and illustrated in figures 7 and 9a of the drawings.

Referring to figure 5, a well logging operation is illustrated. During the well logging operation, a well logging tool 34 is lowered into the earth formation 16 of figure 1 which is penetrated by a borehole 36. In response to the well

logging operation, well log data 38 is generated from the well logging tool 34, the well log data 38 being provided as "input data" to a computer 40a of a well logging truck 40. Responsive to the the well log data 38, the well logging truck computer 40a produces a "well log output record" 42.

Referring to figures 6 and 7, a workstation 44 is illustrated in figure 6. A storage medium 46, such as a CD-Rom 46, stores software, and that software can be loaded into the workstation 44 for storage in the memory of the workstation. In figure 7, the workstation 44 includes a workstation memory 44a, the software stored on the storage medium (CD-Rom) 46 being loaded into the workstation 44 and stored in the workstation memory 44a. A workstation processor 44d will execute the software stored in the workstation memory 44a in response to certain input data provided to the workstation processor 44d, and then the processor 44d will display or record the results of that processing on the workstation "recorder or display or 3D viewer" 44e. The input data, that is provided to the workstation 44 in figure 7, includes the well log output record 42 and the reduced seismic data output record 24a. The "well log output record" 42 represents the well log data generated during the well logging operation in an earth formation of figure 5, and the "reduced seismic data output record" 24a represents data-reduced seismic data generated by the mainframe computer 30 in figure 3 in response to the seismic operation illustrated in figure 1. In figure 7, the software stored on the storage medium (CD-Rom) 46 in figure 7 includes a "Flogrid" software 46a and an "Eclipse" simulator software 46b. When the storage medium (CD-Rom) 46 is inserted into the workstation 44 of figure 7, the "Flogrid" software 46a and the "Eclipse" simulator software 46b, stored on the CD-Rom 46, are both loaded into the workstation 44 and stored in the workstation memory 44a. The "Flogrid" software 46a is fully described and set forth in prior pending Great Britain patent application number 9727288.4 filed December 24, 1997, the disclosure of which is incorporated by reference into this specification. When the workstation processor 44d executes the Flogrid software 46a and the Eclipse simulator software 46b, the "Eclipse" simulator software 46b responds to a set of more accurate grid cell property information associated with a respective set

of grid blocks of a structured simulation grid generated by the "Flogrid" software 46a by further generating a set of more accurate simulation results which are associated, respectively, with the set of grid blocks of the simulation grid. Those simulation results are displayed on the 3D viewer 44e of figure 7 and can be recorded on a recorder 44e.

Referring to figures 8 and 9, referring initially to figure 8, the Flogrid software 46a and the Eclipse simulator software 46b are illustrated as being stored in the workstation memory 44a of figure 7. In addition, in figure 8, the "simulation results", which are output from the Eclipse simulator software 46b in figure 8, are illustrated as being received by and displayed on the 3D viewer 44e of figure 7.

In figure 8, the Flogrid software 46a includes a reservoir data store, a reservoir framework, a structured gridder, an unstructured gridder, and an upscaler, all of which are fully discussed in the above referenced prior pending Great Britain patent application number 9727288.4 filed December 24, 1997, the disclosure of which has already been incorporated by reference into this specification. A set of "simulation grids and properties associated with the grids" 47, generated by the upscaler and the "Petragrid" unstructured gridder, are received in the Eclipse simulator software 46b. In response, the Eclipse simulator software 46b generates a "set of simulation results associated, respectively, with a set of grid blocks of the simulation grids" 48, and the simulation results and the associated grid blocks 48 are displayed on the 3D viewer 44e.

In figure 9, an example of the "set of simulation results associated, respectively, with a set of grid blocks of the simulation grids" 48, which are displayed on the 3D viewer 44e of the workstation 44 of figures 6, 7, and 8, is illustrated in figure 9.

The second section of this specification will provide a detailed description of the Eclipse Office software of the present invention.

Second Section - Detailed Description of the Eclipse Office software

General Discussion

Referring to figures 9a through 15, a general discussion of the Eclipse Office software of the present invention is set forth in the following paragraphs.

In figure 9a, the workstation 44 of figure 7 is illustrated again in figure 9a. However, in figure 9a, the storage medium (CD-Rom) 46 stores the Flogrid software 46a, the Eclipse simulator software 46b, and the Eclipse Office software 46c of the present invention. When the CD-Rom 46 is inserted into the workstation 44, the Eclipse Office software 46c in addition to the Flogrid software 46a and the Eclipse simulator software 46b are loaded from the storage medium (CD-Rom) 46 into the workstation memory 44a of figure 9a. As a result, as shown in figure 9a, the workstation memory 44a now stores three software packages: the Flogrid software 46a, the Eclipse simulator software 46b, and the Eclipse Office software 46c in accordance with the present invention.

In figure 10, the Flogrid software 46a, the Eclipse simulator software 46b, and the Eclipse Office software 46c, stored in the workstation memory 44a, are illustrated again. However, in figure 10, the Eclipse Office software 46c receives certain "raw data" 50 and other data generated by certain "pre-processor programs" 52. The raw data 50 include four types of data: structural data, property data, well data, and fluid properties. The raw data 50 are discussed in detail in the prior pending Great Britain patent application number 9727288.4 filed December 24, 1997 directed to the Flogrid software, the disclosure of which has already been incorporated by reference into this specification. The pre-processor programs 52 include the following software programs which can be purchased or licensed from GeoQuest, a division of Schlumberger Technology Corporation, Houston, Texas, USA: (1) Grid or Flogrid 52a, (2) PVTi 52b, (3) SCAL 52c, and (4) two other programs 52d

including Schedule 52d1 and VFPi 52d2. Each of the pre-processor programs 52a through 52d generate data which are received and collected by the Eclipse Office software 46c for ultimate use by the Eclipse simulator software 46b. In addition, the raw data 50 are received and collected by the Eclipse Office software 46c for ultimate use by the Eclipse simulator software 46b.

In operation, in figure 10, the Eclipse Office software 46c receives the raw data 50 and the data generated by the pre-processor programs 52 and, responsive thereto, the Eclipse Office software 46c will collect all such data and pass such data to the Eclipse simulator software 46b. The Eclipse simulator software 46b be executed by workstation processor 44d of figure 9a. However, during the execution of the Eclipse simulator software 46b by processor 44d, the Eclipse simulator software 46b will receive and use the raw data 50 and/or the data generated by the pre-processor programs 52. During the execution of the Eclipse simulator software 46b, the Eclipse simulator software 46b will be generating a "set of simulation results", and that "set of simulation results" will be passed from the Eclipse simulator software 46b to the Eclipse Office software 46c. When the Eclipse Office software 46c receives the "set of simulation results", the Eclipse Office software 46c will be re-transmitting that "set of simulation results" to the "recorder or display or 3D viewer" 44e of figures 9a and 10 for displaying and/or recording the "set of simulation results" at each point in time. Bear in mind that the "set of simulation results" will be generated from the Eclipse simulator software 46b during its execution by the workstation processor 44d, and that "set of simulation results" will be instantaneously displayed, by the Eclipse Office software 46c, at each point in time on the "recorder or display or 3D viewer" 44e of figure 10. As a result, the Eclipse Office software 46c will instantaneously "display or report results" 44e (see numeral 44e in figure 10) in response to the raw data 50 and/or in response to the data provided by the pre-processor programs 52, during and after the execution of the Eclipse simulator software 46b by the workstation processor 44d. Refer now to figure 11 for a more complete description of this functional operation.

In figure 11, the Eclipse Office software 46c of figure 10 includes a case manager/project manager 46c1, a case builder/data manager 46c2, and a run manager 46c3. The "display or report results" 44e generated on the "recorder or display or 3D viewer" 44e of figure 10 includes a results viewer 44e1 and a report generator 44e2. In response to an output from the run manager 46c3 consisting of a plurality of data (possibly including a plurality of 'test data' compiled by the case manager 46c1) intended to be used by the Eclipse simulator 46b, the Eclipse simulator software 46b will be executed by the workstation processor 44d of figure 9a and, responsive thereto, the Eclipse simulator software 46b of figure 11 will generate a "results file" 54. The results file 54 will be used by the results viewer 44e1 and the report generator 44e2 to display a set of results and to report the set of results on the "recorder or display or 3D viewer" 44e of figure 10.

The functions provided by the case manager 46c1, the case builder 46c2, and the run manager 46c3, in addition to the results viewer 44e1 and the report generator 44e2, will become evident in the following paragraphs with reference to figures 12 through 15 of the drawings.

In figure 12, a dialog or screen display, which is produced on the "recorder or display or 3D viewer" 44e of figure 9a by the case/project manager 46c1 of figure 11, is illustrated. In figure 12, the screen display which is generated by the case/project manager 46b1 of figure 11 consists of a plurality of 'test data' arranged in a tree-like structure. For example, a body of test data is called "new" 56. The "new" test data 56 can be divided into two sub-parts: a first subpart "new-1" 58 and a second subpart "new-2" 60. The first subpart "new-1" 58 is subdivided into two parts: "new-1-0" 62 and "new-1-1" 64. The "new-1-0" subpart 62 can be subdivided into two parts: a "new-1-0-0" subpart 66 and a "new-1-0-1" subpart 68. The other subparts are also subdivided in a similar manner; for example, the "new-1-1" subpart is divided into two parts: the "new-1-1-0" subpart 70 and the "new-1-1-1" subpart 72. The "new-2" subpart 60 is divided into three subparts: "new-2-0" 74, "new-2-1" 76, and

"new-2-2" 78; and the subpart "new-2-0" 74 is itself subdivided into yet another subpart "new-2-0-0" 80.

In accordance with one major aspect of the present invention, the subdivisions of "test data" illustrated in the screen display of figure 12, and generated by the case/project manager 46c1 in figure 12, indicate that the case/project manager 46c1 of figure 11 stores a "plurality of test data", and that test data is subdivided into further subdivisions of test data, and those further subdivisions of test data can be subdivided into yet further subdivisions of test data. The operator sitting at the workstation 44 of figure 9a can select whatever subparts or subdivisions of that "test data" (56 through 80 of figure 12) is desired for the purpose of the use of that test data by the Eclipse simulator software 46b to generate the results file 54 of figure 11. This function will become more evident from a reading of the following description of the Eclipse Office software 46c of the present invention.

In figure 13, a functional block diagram of the case builder/data manager 46c2 of figure 11 is illustrated. The case builder/data manager 46c2 includes a reservoir description 82 consisting of a data base supplied with data originating from either the "case definition" 81 or the Grid or Flogrid preprocessor programs 52a, a PVT data base 84 consisting of data supplied by the PVTi preprocessor program 52b, a SCAL data base 86 consisting of data supplied by the SCAL preprocessor program 52c, two blocks entitled "initialization" 88 and "summary" 90, and a Schedule/Production database 92 supplied with data originating from the Schedule 52d1 and the VFPi 52d2 preprocessor programs 52d.

The case builder/data manager 46c2 allows the operator sitting at the workstation 44 of figure 9a to receive a "case definition" 81 from the case/project manager 46c1. The "case definition" 81 consists of a plurality of the 'test data' 56 through 80 of figure 12 which are selected by the operator viewing the display screen of figure 12 and are adapted for use by the Eclipse simulator software 46b. The case builder/data manager 46c2 allows the

operator sitting at workstation 44 to edit the test data disposed within that case definition 81 prior to submission of the edited test data to the Eclipse simulator software 46b.

In figure 13, assume that the operator has selected one or more of the subparts or subdivisions of the test data 56 through 80 of figure 12, and that those one or more subdivisions of test data 56 through 80 now comprise the "case definition" 81 of figure 13. That "case definition" 81 is received by and forms the "reservoir description" 82. Alternatively, the reservoir description 82 could comprise data originating from the Grid or Flogrid preprocessor programs 52a. In addition, the PVT database 84, the SCAL database 86, and the Schedule/Production database 92 are each formed by receiving data from their respective preprocessor programs 52b, 52c, and 52d. Now that the above referenced databases are formed, the case builder/data manager 46c2 will produce a simulation file 94. The simulation file 94 of figure 13 is sent by the case builder/data manager 46c2 of figure 11 to the run manager 46c3 of figure 11.

In figure 14, a functional block diagram of the run manager 46c3 of figure 11 is illustrated. The run manager 46c3 can select vectors if applicable, block 96 of figure 14. If the simulation file 94 from the case builder 46c2 is too large, in order to avoid overloading memory, the run manager 46c3 can select certain vectors associated with only a "subset of the simulation file" 94, and then the run manager 46c3 will submit only that "subset of the simulation file" 94 to the Eclipse simulator 46b for use by the simulator 46b during its execution by the workstation processor 44d of figure 9a. As a result, in response to the receipt by the simulator 46b of only that "subset of the simulation file" 94, the results file 54 of figure 11 will contain a "subset of results" associated with the "subset of the simulation file" 94. That "subset of results" can be monitored on the results viewer 44e1 or reported via the report generator 44e2.

In any event, in figure 14, the simulation file 94, or the "subset of the simulation file" 94, will be submitted to the Eclipse simulator software 46b,

block 98 in figure 14. During the execution of the Eclipse simulator software 46b by the workstation processor 44d, the simulation file 94 (or the "subset of the simulation file" 94) will be used by the simulator 46b, and, responsive to that execution of the simulator software 46b, a display will be produced on the "recorder or display or 3D viewer" 44e of figure 9a, that display representing and corresponding to the test data in the "simulation file" 94, or to the test data in the "subset of the simulation file". In figure 14, the run manager 46c3 will "monitor the run on the display", block 100 in figure 14. In fact, the run manager 46c3 will instantaneously monitor the execution of the simulator software 46b, during its use of the simulation file 94; and that monitoring will take place instantaneously and at each point in time during the execution of the simulator software 46b.

In figure 15, a functional block diagram of the "display or report results" 44e of figure 11, and of the "results file" 54 of figure 11, is illustrated. In figure 15, the results file 54 will include information or "simulation results" which pertain to grids 54a, summary 54b, restart 54c, and initialization 54d. In figure 15, the "display or report results" 44e includes the results viewer 44e1 and the report generator 44e2 of figure 11; however, the "display or report results" 44e of figure 15 will also "open the summary" 44e3 (that is, it will open the summary 54b results file), "select vectors" 44e4, "open grids" 44e5 (that is, open the "grids" 54a results file), and "open restart and initialization" 44e6 (that is, open the restart 54c and the initialization 54d results files). When the summary results file 54b is opened by the open summary block 44e3, and the grids results file 54a and the restart results file 54c and the initialization results file 54d are also opened by blocks 44e5 and 44e6 of figure 15, all the "simulation results" stored in the results files 54 of figure 15 will be made available to the results viewer 44e1 (which will display those "simulation results") and to the report generator 44e2 (which will select reports and solutions and generate a written report for management that will document those "simulation results").

A functional description of the operation of the Eclipse Office software 46c of figure 10 of the present invention, and, in particular, of the case/project manager software 46c1 of figures 11 and 12 of the Eclipse Office software of the present invention, will be set forth in the following paragraphs with reference to figures 9a through 15 of the drawings.

In figure 9a, the CD-Rom 46 has stored thereon the Flogrid software 46a, the Eclipse simulator software 46b, and the Eclipse Office software 46c. That CD-Rom 46 is inserted into the workstation 44 of figure 9a, and the Flogrid software 46a, the Eclipse simulator software 46b, and the Eclipse Office software 46c are loaded from the CD-Rom 46 for storage into the workstation memory 44a of the workstation 44 of figure 9a. When the Flogrid, Eclipse simulator, and Eclipse Office software are stored in the workstation memory 44a, one configuration of that software stored in memory 44a is illustrated in figure 10. In figure 10, certain "raw data" 50 is provided to the Eclipse Office software 46c. In addition, certain other input data, provided by the preprocessor programs 52 of figure 10, are also provided to the Eclipse Office software 46c. In figure 11, that raw data 50 and the other input data from the preprocessor programs 52 are provided as "input data" to the case builder/data manager 46c2 of figure 11.

However, in addition to the input "raw data" 50 and the other input data originating from the preprocessor programs 52 (which are all being made available to the case builder 46c2 of figure 11), the case/project manager 46c1 of figure 11, in accordance with one major aspect of the present invention, also contains a plurality of additional "test data" which can also be made available to the case builder/data manager 46c2. That additional "test data" is illustrated in figure 12. In figure 12, that additional "test data" is stored in the case/project manager 46c1 in a "tree-like" fashion. That is, the "test data" is stored in the case/project manager 46c1 of figure 12 by storing and organizing that test data in the form of a tree. For example, the broadest category of the test data stored in the case/project manager 46c1 is the "new" 56 test data of figure 12. However, if the user/operator wants to select certain other subsets

of that "new" 56 test data, the operator would then select either "new-1" 58 subset test data, or the "new-2" 60 subset test data. On the other hand, if the operator wants to select still other subsets of the "new-1" 58 or the "new-2" 60 subset test data, the operator can select any one or more of the following subsets of the test data: subsets 62, 64, 66, 68, 70, 72, 74, 76, 78, or 80 of figure 12. Each subset of the test data of figure 12 contains certain unique parameters which are useful when running the Eclipse simulator software 46b. As a result, the operator sitting at the workstation 44 of figure 9a may want to select one or more of the subsets of test data 56 through 80 in figure 12 in order to study the resulting "results" stored in the results files 54 which are generated when the selected one or more subsets of test data 56 through 80 are used by the simulator 46b. The operator can study those "results", stored in the results files 54, by viewing those "results" on the results viewer 44e1 or reading a report of those results on a report generated by the report generator 44e2.

In any event, in figure 11, if the raw data 50 is received by the case builder 46c2, the case builder 46c2 will allow the operator to edit that raw data 50, and the case builder 46c2 of figure 11 will present the edited raw data 50 to the run manager 46c3 for submission to the Eclipse simulator 46b. On the other hand, if the data from the preprocessor programs 52 are received by the case builder 46c2, the case builder 46c2 will allow the operator to edit the preprocessor program 52 data, and the edited preprocessor program data will be submitted to the run manager 46c3 for submission to the Eclipse simulator 46b. However, if the operator selects one or more of the subsets of test data 56 through 80 in figure 12, that test data (56 - 80) will be submitted to the case builder 46c2 of figure 11, and the case builder 46c2 will allow the operator sitting at the workstation 44 to edit that test data (56 - 80). The edited test data (56 - 80) will be submitted to the run manager 46c3. The run manager 46c3, in figure 14, will submit the edited test data (56 - 80) to the Eclipse simulator 46b, block 98 in figure 14, and the run manager will monitor the execution of the Eclipse simulator 46b on the "recorder or display or 3D viewer" 44e of figure 9a, block 100 of figure 14. In figure 11, when either the edited

raw data 50, or the edited preprocessor program data 52, or the edited test data (56 - 80) are submitted to the Eclipse simulator software 46b, and when the Eclipse simulator software 46b is executed by the workstation processor 44d in response to that data, the Eclipse simulator software 46b will generate a set of "results files" 54 in figure 11. Those "results files" 54 will be made available to the results viewer 44e1 (of the display 44e of figure 9a) and to the report generator 44e2 (of the recorder 44e of figure 9a). The operator sitting at the workstation 44 can view those results on the display 44e via the results viewer 44e1, or can read a report of those results which is generated by the report generator 44e2. In actual practice, in figure 15, the "display or report results" 44e will open the summary results file 54b, open the grids results file 54a, open the restart results file 54c, and open the initialization results file 54d. At this point, all the set of "simulation results" files which are stored in the "results file" 54 will be opened, and the "simulation results" are available to the results viewer 44e1, and to the report generator 44e2. As a result, during the execution of the Eclipse simulator software 46b in figure 11, certain "simulation results" will be stored in the results files 54, and those "simulation results" will instantaneously be made available to the operator at workstation 44 by instantaneously displaying those "simulation results" in the results files 54 on the results viewer 44e1, and instantaneously reporting those "simulation results" in the results files 54 on a written report which is generated via the report generator 44e2.

A more detailed description of the structure and the functional operation of the Eclipse Office software 46c of figures 10 and 11 of the present invention is set forth in the following paragraphs of the "Detailed Discussion" with reference to figures 16 through 29 of the drawings.

Detailed Discussion

Refer now to figures 16 through 29.

As a result of advances in technology over the last few years, the reservoir engineer must manage more data and make better informed decisions in a shorter period of time. That technology has enabled more data to be incorporated, more complex models to be built, and more realizations to be studied. However, as a further result, more data must be managed, more models must be created, and more results must be analyzed. The Eclipse Office software 46c of figure 10 provides the tools which allow the reservoir engineer to efficiently manage these tasks and thus concentrate on the engineering input and analysis. Consequently, the Eclipse Office software 46c will allow the reservoir engineer to create his model quickly, manage his data efficiently, and control his run effectively. The Eclipse Office software 46c: allows for the import of raw data required for a simulation, contains a suite of base level tools allowing the creation and manipulation of engineering data required for a simulation, and provides a means for using more advanced tools within external packages to manipulate the data. Therefore, the Eclipse Office software 46c will provide an environment for all simulation related tasks (create/view/edit/manage data, view/analyse results, control/submit runs, and generate reports). Furthermore, the Eclipse Office product removes the need for manual editing of data, removes the need for macros to run individual programs, it is intuitive for a novice user, and it is complete for the experienced user.

1.0 Introduction

The Eclipse Office software 46c of figure 10 will provide the user with an environment within which engineering analysis can be conducted. These analyses will initially be focused on numerical simulation; however, the Eclipse Office software 46c design allows other engineering techniques to be used should new modules be developed. The following paragraphs will set forth both the engineering requirements and the specifications of the Eclipse Office software 46c, and establish its relationships to other products.

User Profile

The Eclipse Office software 46c of figure 10 will become the preferred method of performing simulation related activities, and it will be an environment within which it will be possible to easily and efficiently conduct the full range of reservoir engineering tasks.

The expected users of the Eclipse Office software 46c will be petroleum engineers. The end users must have knowledge of the process or simulation, since the natural flow of the Eclipse Office product will follow this process.

2.0 Requirements

Major limitations restricting the growth of reservoir simulation are in its ease of use, level of required experience, and quantity of input data. These impact the market in different ways but all reinforce the idea that simulation is difficult and time consuming. In addition, reservoir engineering analysis (such as decline curve, material balance, or simple network analysis) are often conducted using spreadsheets, and yet the raw data for these are the same as the raw data for simulation. While the Eclipse Office software 46c is a self contained product, in terms of its data generation and analysis tools, it requires a knowledge of the system in which it is installed, and the availability of other software products, especially the simulator engines. The main work path through the Eclipse Office product is illustrated in figure 16.

Referring to figure 16, the Eclipse Office software 46c workflow or functional block diagram is illustrated. In figure 16, the Eclipse Office software 46 workflow starts with project setup, 102, followed by case definition, 104. The next step involves defining and analyzing reservoir properties, 106. The model is run, 108. The operator will now manage the run, 110, analyze the results and produce a scenario report, 112, and produce a case report 114. When analyzing the results and producing the scenario report (112), different scenarios can be selected (see case/project manager 46c1 in figure 12) and steps 106 through 112 can be repeated.

The Eclipse Office software 46c concept provides three main functions: (1) it provides a structured, easy to use means to generate numerical reservoir models quickly, (2) it manages input and output data, and (3) it executes existing pre and post processors. The integration of existing, other software products into the Eclipse Office environment allows those other products to provide their fully advanced functionality in a seamless fashion. The construction of a simulation grid, for example, can be achieved simply with the tools available in Eclipse Office, however, more advanced and complex geological models could be constructed by called Grid and Flogrid as submodules.

Functional Requirements

It is essential that base functionality is both simple to use and and robust. The Eclipse Office product will be used across the hardware range from PC's to UNIX workstations, and therefore it should not require high end graphics performance. The Eclipse Office software 46c should be as memory efficient as possible, ideally being able to run on a minimum configuration of a 486/66 PC with 20 Mb of RAM.

Data Management

The Eclipse Office software 46c of figure 9a and 10 is capable to do the following:

(1) read existing Eclipse simulator software 46b simulation decks and determine relevant sections,
(2) keep a record of all data dependencies between scenarios and prevent conflicting situations before ruining the simulation,
(3) validate individual data sections to ensure all options selected have all relevant data specified,
(4) support data communication to/from the simulator engines,

(5) support data communication to/from Flogrid (recall that the "Flogrid gridding software" is disclosed in prior pending Great Britain patent application number 9727288.4 filed December 24, 1997, the disclosure of which has already been incorporated by reference into this specification),
(6) support data communcation to/from the PVTi preprocessor program 52b of figure 10,
(7) support data communication to/from the Schedule preprocessor program 52d1 of figure 10, and
(8) support data communication to/from the SCAL preprocessor program 52c of figure 10.

Reservoir Description 82 of figure 13

The Eclipse Office software 46c provides tools to allow for the generation of grid geometry and grid properties, including maps, faults, boundaries, wells, aquifers, layers, grid properties, simulation grid builder, and general. Each of these will be discussed in detail, as follows:

(1) Maps
- □ Import of maps (CPS-3, ZMAP+, ascii generic)
- □ Ability to digitize contour maps (multi-contour and single point contour, e.g., porosity at well locations)

(2) Faults
- □ Import of vertical fault traces (ascii generic)
- □ Ability to digitize fault traces
- □ Ability to edit fault trace
- □ Ability to set variable transmissibility multipliers along fault length

(3) Boundaries
- □ Import of reservoir boundaries (ascii generic)
- □ Ability to digitize reservoir boundaries
- □ Ability to edit reservoir boundary shape

(4) Wells
- □ Import of well locations (ascii generic)

- Ability to digitize and edit well locations (vertical and horizontal) - supports manual entry of well coordinates
- Ability to read and display deviated well tracks

(5) Aquifers

- Ability to attach aquifers as boundary conditions
- Ability to define aquifer volume and properties
- Ability to supply/enter aquifer influence tables
- Ability to define aquifers as numerical or analytical

(6) Layers

- Ability to supply a single top or base map, and a thickness map for each layer
- Ability to supply constant values across a reservoir layer (e.g., thickness, porosity, permeability, etc)
- Ability to attach the same map to more than one layer
- Ability to support a mixture of top/base maps with thickness maps to allow explicit shale modeling

(7) Grid Properties

- Ability to sample maps to set grid properties (real numbers)
- Ability to sample map/property to set logical grid properties (integers - e.g. rock type)
- Ability to supply (and store) mathematical correlation relating one property (e.g. porosity or depth) to another (e.g, permeability) and provide means of varying that based on a third (non-simulation) property (e.g., clay volume, or rock type)
- Ability to globally or locally set kv/kh
- Ability to provide local cell value modifiers in the form of multipliers (to be varied by scenario)
- Ability to view, set, and edit properties on an areal or vertical region basis (e.g., constant porosity across this region) including those of a single cell either graphically or via a keyword editor
- Ability to view grid properties on an areal or cross section viewer

- ☐ Ability to contour, map and display derived grid properties (such as calculated hydrocarbon pore volume thickness) and save/copy these contours to a new map
- ☐ Ability to read simulator output files an input

(8) Simulation grid builder - support for the creation (and editing) of corner point geometry grids will be provided by Grid and Flogrid

- ☐ Ability to generate multi-layer PEBI grids based on well locations, faults and reservoir boundaries
- ☐ Ability to generate a fixed cell size (e.g., 200 m) grid within a given boundary
- ☐ Ability to generate both 2D and 3D single well (radial) models
- ☐ Ability to generate a cross sectional model
- ☐ Ability to sub divide reservoir layers for simulation
- ☐ Ability to generate local cartesian and radial grid refinements
- ☐ Ability to enter flux boundary locations and generate the flux files from a base run and support new case generation utilizing those fluxes automatically

(9) General

- ☐ Ability to keep grid geometry separate from cell properties to allow different scenarios to be run on exactly the same grid
- ☐ Ability to read existing block center and corner point grids for display
- ☐ Ability to read existing grid properties for display and contouring purposes (only final values need be stored - e.g., in case when multiple edits have been made in existing data deck)
- ☐ Ability to read and display existing LGR definitions (but not edit unless created in Eclipse Office initially)
- ☐ Ability to call "Grid" (and ultimately "Flogrid") to build simulation grids and properties
- ☐ Ability to read and display existing regional definitions (e.g., flux regions, rock type regions, etc)
- ☐ Must write full grid geometry file, and initial properties file for post processing

- Ability to view and edit engineering input (e.g., the map or correlation used to generate the property), keyword input (the simulator input), or graphically (color filled block display)
- Ability to support user supplied include files (for third party applications)

Fluid Properties

PVT (see block 84 of figure 13)

The Eclipse Office software 46c of figures 9a, 10, and 11 will:

- provide correlations and simple equations of state to generate PVT properties for: water, dead oil, volatile oil (including multiple undersaturated curves), gas condensate, dry gas, and "n" component mixtures,
- provide graphical, keyword and engineering (correlation panel) displays of these PVT properties; these should be a phase plot for compositional models and GOR/Bo/uo vs P for black oil (similarly for gas),
- support the reading and editing of existing keyword files in keyword form, and store regional variations as specified,
- support the calling of PVT/PVTi to generate PVT properties,
- support the variation of PVT properties with depth (GOR/bubble point pressure, Bo, oil API, fluid composition) as well as regional variations
- support the use of the underlying calculator to generate these properties should a user have a preferred correlation,
- support passive phase tracers,
- support active brine tracking, and the variation of water properties with salinity,
- support non-isothermal and isothermal runs, including the variation of PVT properties with temperature, and
- support the setting of the rate of gas resolution/gas vaporization.

SCAL (see block 86 in figure 13)

The Eclipse Office software 46c of figures 9a, 10, and 11 will:

- □ support generation of relative permeability curves through Corey exponents, including regional variation of end points and exponents,
- □ support direct entry/file import of relative permeability curves, and regional variation,
- □ accept and support normalized relative permeability and capillary pressure curves,
- □ support J Functions for capillary pressure generation,
- □ support use of end point variation vs depth and a function of other parameters (e.g. rock properties)[to denormalize curves], and
- □ support the calling of the SCAL program for more detailed analysis.

<u>Specification of initial contacts and pressures</u>

The Eclipse Office software 46c of figures 9a, 10, and 11 will support three ways to specify initial conditions: (1) Equilibration, (2) Enumeration, and (3) Restart (Standard and SAE/LOAD). Each of these three ways, plus an additional general set of support conditions, will be discussed below, as follows:

<u>Equilibration</u> - The Eclipse Office software 46c will:

- □ support the entry of initial contact depths and reference pressure,
- □ support the reading of an existing data file to set (and allow editing of) initial contact depths and reference pressures,
- □ support regional variation of contacts and pressures,
- □ support threshold pressures between regions/along faults to control flow between equilibration regions, and
- □ support "enhanced" options, such as improved fluid in place calculations.

<u>Enumeration</u> - The Eclipse Office software 46c will support the setting of all relevant arrays through one of the following means:

- explicit setting - single value/cell through keyword editor or include file,
- calculated setting - provision of pressure and saturation profile through use of calculator

Restart - The Eclipse Office software 46c will support the restarting of a run (using the same grid) from its base run. Restart should be date or report step specified, and the user should see all available restart dates. The Eclipse Office software 46c must ensure that the Schedule section is in line with this date through use of SKIPREST keyword.

General - The Eclipse Office software 46c:

- will support the initialization of a simulation model for fluid in place determination,
- could be extended to support general material balance analysis, and
- could be extended to support RFT pressure analysis to compare and set regional variations in contacts and gradients.

Set up of well and gathering tree information

General:

The Eclipse Office software 46c sill support the intuitive and easy to use interface of areal well locations, the ability to double click for item editing, and drag and drop (where appropriate). Editing can be facilitated by double clicking on a well (etc) or clicking with the right mouse button for a drop down menu. The Eclipse Office software 46c will support an easy method of setting controls for multiple wells/groups at a time. This could be achieved by rubber banding, CTRL-clicking, wildcarding or some other means. In addition, the Eclipse Office software 46c will call the VFPi preprocessor program (52d2 of figure 10) to construct pipeline and well lift curves.

Wells:

The Eclipse Office software 46c will:

- support the reverse engineering of existing input decks to determine an approximate (x, y) location from the cell (i, j) and other interpretable information (rates, kinds, status, etc),
- support vertical, deviated and horizontal wells, and determine the completed cells,
- support the entry of well completed intervals based on depth or logical representations (e.g. oil leg, water leg, gas cap, layers 1-4, 9000-9500 ft)
- call the Schedule preprocessor program 52d1 of figure 10 to handle complex analyses,
- support the variation in time of:
  - well rates and targets (oil, water, gas, liquid, bhp, thp),
  - well controls (rate specified, pressure control etc),
  - well kinds (injectors, producers),
  - well status (open, close, queue for drilling),
  - well downtime factors,
  - well lift curve,
  - completed interval properties (skin, kh, datum, depth, etc), and
  - well workover parameters,
- support one value per time/report step - it will not interpolate or average historical data, and
- support the concept of drilling queues, and be able to 'spot' future wells on its areal display.

Groups:

The Eclipse Office software 46c will:

- support the flexible generation of well groups through:
  - reading an existing data deck,

- graphically providing icons for group nodes and setting sons (wells of groups) through drag/drop - note: multiple sons can be specified by rubber banding, CTRL clicking, etc, to highlight a number of items before drag/drop, and
- graphically setting and highlighting (in different color) groups with no direct control mode,

- support the variation in time of:
  - group rates and targets (oil, water, gas and liquid),
  - group controls (rate specified, potential/guiderate controlled, no control)
  - group controls (production/injection targets, voidage replacement, re-injection)
- support the import of fluids of a different composition/phase for re-injection/top-up,
- support the definition of a separator train and its conditions,
- support the setting up of gas field sales contracts, and
- support the concept of 'equipment':
  - gas plants,
  - well head chokes,
  - satellite injection/production, and
  - compressor/pumps and their fluid consumption (note: equipment may be placed at any node in the group hierarchy).

Networks:

The Eclipse Office software 46c will:

- support the definition of line properties and the attachment of VFP tables to network branches,
- support the setting of group nodes as manifolds (common pressure points), and
- support the setting of fixed pressure nodes.

Output Controls

In general, the role of the ASCII print file should be de-emphasized. All tabular output should be able to be generated from the graphics/restart files. The Eclipse Office software 46c will generate a standard list of output which will ensure the standard engineering analyses can be conducted. Specifically, this list needs to contain: (1) field, group and well rates (oil, water, gas, liquid), (2) field, group and well pressures (field datum average pressure, node pressures well bhp, thp if setup), (3) field, group and well cumulatives, and (4) cell pressures (datum corrected) and phase saturations.

The Eclipse Office software 46c will support the selection features by topic and automatically generate a list of applicable (optional) output for this run - e.g., if tracers are present in the run, then automatically select all tracer outputs, but allow user to disable those if required. This list should also contain simulator performance vectors. In addition, the Eclipse Office software 46c will support panel selection for grid based properties. These should be written to graphics files for subsequent viewing graphically or in a tabular form.

Multiple Scenarios

Once enabled, the multiple scenario option should simply present the end user with a list of variables that can be "scenarioised" (i.e., made into scenarios). Individual scenarios are then created simply by changing the relevant section to reflect the ranges of that parameter to be used.

The Eclipse Office software 46c will support the ability to "scenarioise" the following parameters: (1) fault multipliers, (2) grid properties (including correlation parameters - to allow support for calculator generated properties), (3) grid cell size (for regular cartesian grids), (4) relative permeability curves (Corey exponents and table end points), (5) initial contact depths, (6) initial pressures, (7) aquifer parameters (size, strength), (8) PVT correlation parameters, (9) well targets and limits (rates and pressures), (10) group targets,

(11) drilling queues, and (12) well workover parameters (water cut/GOR limits, etc).

The Eclipse Office software 46c will support the use of different include files for each scenario - note: this will allow support of external products to setup multiple scenarios (e.g. PVT or GRID). The Eclipse Office software 46c will keep track of these scenarios and allow submission of all or a particular grouping automatically.

Job Submission and Control

The Eclipse Office software 46c:

- will support both local and remote platforms for execution of simulation jobs,
- will allow jobs to be queued (internally) so that memory is efficiently used,
- will allow job prioritization (e.g. small quick jobs should be able to jump in front - both interactively and in batch)
- will allow viewing of current jobs, the job queue, and job status,
- should support an underlying queue structure where installed,
- will support multiple scenarios to be singly submitted and queued,
- will support an option of interactive results viewing with all of the functionality of the results viewing module,
- will allow interactive simulator control with the following options:
    - abort run
    - pause run
    - advance to next report step, write restart (optional) and stop

Viewing and Analysis of Results

This module must be available while a simulation model is proceeding. The viewing and analysis of results needs to be highly intuitive - extensive use

should be made of mouse clicks to obtain point/cell values or to set particular attributes (e.g. line or axis attributes).

The Eclipse Office software 46c will:

- ☐ support a number of standard plot types (e.g. well phase rates vs time, well bhp vs time). These standard plot types should then be available for wells/groups/etc at the click of a mouse button; the default x axis needs to be calendar years,
- ☐ support the user configuration of the standard plot types, including defining additional ones,
- ☐ support the plotting of user entered/supplied data along with simulation results,
- ☐ support the creation of user vectors/solutions through the underlying calculator,
- ☐ support 2D areal and cross section solution views that can be stepped through time both manually and automatically; interactive interrogation of cell values should be supported on both views,
- ☐ support color filled contouring of results
- ☐ support the clicking of well/group/platform to plot its rate history (these plots should be user definable),
- ☐ call GRAF for more flexible and batch plotting options; the Eclipse Office software 46c will create the relevant GRF for loading the data automatically into GRAF,
- ☐ support generation of tabular based output currently written in fixed form to the ASCII print file; specifically, the generation of Fluid in Place and well reports need to be supported,
- ☐ support the generation of monthly/quarterly/annual averages of rate data - note: this could be via the Schedule preprocessor program,
- ☐ support viewing of cell based data either graphically or in its tabular matrix form,
- ☐ support the analysis of multiple scenarios through parameterization,
- ☐ support curve fitting/regression for experimental design,

- support a flexible means (wildcard/rubber banding/CTRL clicking) to gather data to line plot - note: an option here should be the ability to sum these data items together to produce a total pot for the flexible group, and
- support an easy to use means of selecting variables to plot - this should not just be a list of mnemonics.

Report Generation

The Eclipse Office software 46c will:

- provide a series of pre-defined report templates,
- generate formatted input to a spreadsheet for economic analysis,
- support calculator scripts to conduct analysis not directly supported, and
- generate reports on: (1) scenario basis, (2) case basis - comparing scenarios and giving spread, (3) project basis - comparing anything.

Walkthroughs

The following two examples are presented which will demonstrate the usefulness of the Eclipse Office software 46c.

Case 1 - New Model

A user is running on a networked personal computer.

First, define the project. This includes the title, directory, areal extent, and primary units system.

Second, create the case. This includes defining phases, and selecting treatment (isothermal, compositional, etc).

Third, define data. This includes:

(1) building a reservoir model by: loading tops map, loading faults, entering layer properties, entering well locations and providing porosity values to generate poro map (interpolate and sample), generating x/y permeabilities through poro/perm correlation, and setting kv/kh,
(2) setting fluid properties by PVT correlation,
(3) setting relative permeability and capillary pressure data (Corey exponents and J function),
(4) setting initial contacts and reference pressure, and
(5) setting well data by: setting completed depths, targets and rate limits, spotting new wells that could be drilled, defining group/gathering structure, setting equipment limits/controls as field/separator level (injection capacities, separator limits, etc), and setting injection and reinjection controls.

Fourth, run simulation model. Observe results, and decide that the run has fallen off plateaux rate too early, so kill the job. Modify existing scenario to add drilling queue. Re-run through to the end.

Fifth, plot and analyze results. Generate plots of: field oil rate vs time, cumulative oil vs time, field oil rate vs cumulative oil, field pressure vs cumulative oil, and average well bhp over all producers against time and add field pressure to plot. Create a standard report including plots in relevant places.

Case 2 - Existing data model

First, define the project. This includes title, directory, areal extent, and primary unites system.

Second, create the case - initialize all data.

Third, create a new multiple scenario. This includes the following:

(1) change fault multipliers (defined using "Faults" keyword,

(2) change PVT

(3) change to black oil, through correlation, and plot against old PVT

(4) add two new wells, set guiderates and pressure limits

(5) change group limits to add new group

(6) submit model to run for 10 years

(7) analyze results

(8) create new scenario

(9) restart from 5 years, adding 2 new wells to an existing group

(10) run model

(11) plot results and compare last 5 years on both

(12) add original compositional results by reading existing summary files

(13) read user data file of measured well RFT pressure vs depth at time of 1 year, and compare to simulated response

(14) save and quit project

3.0 Specifications

The Eclipse Office Data Model

In the Eclipse Office software 46c data model, there will be a database to hold the structure of the project. The project is made up of a base case, which is a simulator input file. From the base case, many cases and scenarios can arise in a tree like structure.. These are, in fact, simulator input files. For each case, the database will hold the following information:

- case definition,
- Include filenames for each section of the simulator input.

Each section of the Case Builder/Data Manager 46c2 of figure 11 in the Eclipse Office software 46c will produce an Include file for the case (the grid geometry and the properties will be separate from the Include files). The Include files produced by the Eclipse Office software 46c contain additional information as

comments, e.g., PVT correlation types, Temperature, Gas Gravity, etc. Although the user can save intermediate files as Include files, there is no method for tracking these, e.g., saving different PVT correlations.

Application Layout

Refer now to figure 17 for a dialog depicting the Eclipse Office software 46c application layout.

In figure 17, a screen display is illustrated, and that screen display is displayed on the display 44e of figures 9a and 10 upon start-up. There will also be a log window displayed. The main window of figure 17, however, consists of a menu bar, preprocessor pushbuttons (Flogrid, PVTi, SCAL, Schedule, VFPi) and post processor push buttons (Graf, RTView, HM), and Eclipse Office software 46c modules displayed as push buttons (Project, Data, Execute, Results, Report, Exit).

Menu Bar Items

File

- ☐ Open - file dialog for database files
- ☐ ASCII Read - file dialog for ascii database files
- ☐ About - panel to show/enter project details
- ☐ Save - saves current database file
- ☐ Save As - file dialog to save new database file
- ☐ ASCII Write - file dialog to save new ascii database file
- ☐ close - closes current database
- ☐ Exit - exits the program

Module

- ☐ Project
- ☐ Data
- ☐ Execute

- Results
- Report

Options

- Units - choice between oil field, metric, etc
- Directories - panel

- Configuration - submenu
    - system - panel with network information
    - software - panel with installed pre/post processor programs/versions
    - simulator - panel with simulator options - note: the software and simulator options will come from decoding the Password with the Configuration file

Utilities

- About - displays panel with Eclipse Office details
- Calculator - general calculator facility
- Text Editor - general editing facility

Window

- Tile
- Cascade
- Minimise - general window facilities
- Restore
- Log Window

Help

- About - interactive on-line help system

Pre/Post Processor Push Buttons

- Pressing the button will launch the selected program

<u>Eclipse Office software 46c Modules</u>

Pressing the Eclipse Office module pushbuttons of figure 17 (i.e., the "Project" module pushbutton, the "Data" module pushbutton, the "Execute" module pushbutton, the "Results" module pushbutton, the "Report" module pushbutton, and the Exit module pushbutton in figure 17) will bring to the

front the selected module. Let us now consider each of the Eclipse Office modules individually below.

"Project" module - the Case/Project Manager 46c1 of figure 11

Workflow

In figure 18, a workflow or functional block diagram associated with the Case/Project manager 46c1 of figure 11 is illustrated. In figure 18, the functional block diagram of the Case manager 46c1 includes the following: (1) problem definition 116, (2) Project Specification (units, directories, areal location) 118, (3) Under Project specification, Specification of phases and treatment 120, and (4) Under Project Specification, specification of optional extensions 122.

Layout

In figure 19, a dialog depicting the Case/Project manager 46c1 layout is illustrated. The Case/Project manager 46c1 layout (or "window screen display") consists of a Menu Bar, Icons, and the current Project displayed as a hierarchical tree structure. Below is the screen displayed on entry to the Case/Project manager if an existing project has been opened. The display area will be blank if the project is empty.

Nomenclature

Base - first simulator run of the current project
Case - any subsequent simulator run where the grid geometry has been changed from its parent
Scenario - any subsequent simulator run where the grid geometry remains the same as its parent
Case and Scenarios will be color coded.

Menu Bar Items

File
- ☐ Track - file dialog to select file and view history of file
- ☐ Close - closes Project Manager module

Case
- ☐ About - panel to show/enter case details
- ☐ View - views input and output files associated with selected case/scenario
- ☐ Load - loads selected case/scenario
- ☐ Load As - loads selected case/scenario as a new case/scenario
- ☐ Create - creates a new case/scenario from an existing simulator run
- ☐ Delete - removes selected case/scenario and all children from project

Options
- ☐ Base - will set the selected case/scenario as the Base case
- ☐ Restart - displays restart tree if selected case/scenario is a restart run

<u>"Data" module - the Case Builder/Data Manager 46c2 of figure 11</u>

Workflow

In figures 20a and 20b, a workflow or functional block diagram associated with the Case Builder/Data manager 46c2 of figure 11 is illustrated.

Refer now to figure 20a for the initial blocks of the functional block diagram of the Case Builder 46c2.

- ☐ Define and Analyze Reservoir Properties - block 124
  - ☐ Structure
    - ☐ Boundaries - block 128
    - ☐ Structure Maps - block 128
    - ☐ Faults - block 128

        - Aquifer definition - block 128
    - Geometry - block 130
        - PEBI - block 132
        - Cartesian block gridder - block 132a of 132
            - cross section generator - block 133
        - Radial Gridder - block 134
        - Detailed Gridder via Flogrid - block 134
    - Rock Properties - block 136
        - map sampling - block 138
        - correlation (e.g. poro/perm) - block 138
        - constant properties - block 138a of 138
            - by layer - block 140
            - by areal painter - block 140
    - PVT - block 142
        - correlation - block 144
        - Simple EoS - block 144
        - Detailed Analysis (via PVTi) - block 144
        - Direct Input - block 144
        - Region Painter - block 144

Refer now to figure 20b for the remaining blocks of the functional block diagram of the Case Builder 46c2.

- Define and Analyze Reservoir Properties - block 146
    - SCAL - block 148
        - Corey Exponents - block 148
        - Detailed Analysis via SCAL - block 148
        - Direct Input - block 148
        - Region Painter - block 148
    - Initialization - Block 150
        - Contacts and Static Pressure - block 150
        - Region Painter - block 150
            - simple RFT pressure vs. Depth analysis

- ☐ Calculated (Enumeration) - block 150
- ☐ Material Balance Analysis - block 150
  - ☐ STOOIP determination
- ☐ Restart from previous run - block 150

☐ Wells, Groups and Network - block 152

- ☐ Wells - block 152
  - ☐ Detailed Analysis via Schedule
  - ☐ Basic setup (as in PEBI)
  - ☐ Decline curve analysis
- ☐ Group and Network Setup - block 152
  - ☐ Network hierarchy
  - ☐ Lift curve analysis via VFPi
  - ☐ Prediction generator

☐ Output - block 154

- ☐ Frequency

Layout

Refer now to figure 21 which illustrates a dialog depicting the Case Builder/Data Manager (46c2 of figure 11) layout.

In figure 21, the Case Builder/Data Manager (46c2 of figure 11) window or screen display consists of a menu bar, preprocessor push buttons, icons and a display of the current model (case/scenario) representing the model area together with the wells. This will be blank if a new project.

Menu Bar Items

File

☐ Close - closes Data Manager module

Section

☐ Define

- Description
- PVT
- SCAL - opens the selected section
- Initialization
- Schedule
- Output

Modules

- Case Definition - the case definition section consists of "Menu Bar Items" and "Folder Items" specifying the simulator, model type, phases and other options
    - Menu Bar Items
        - File
            - Close - closes case definition section
    - Folder Items
        - General
            - Simulator - Black Oil, Compositional or Thermal
            - Start Date
            - Title
            - Model Type - 3D, X-section, Radial, 1-D
            - Run type - Restart, load/Save
        - Phases
            - Oil, Water, Gas, dissolved Gas, Vaporized Oil, Gas-Wat
        - Options
            - Tracers, Temp, API, Dual Poro, Miscible
        - Solution
            - Impes, Fully Implicit, AIM, IMPSAT

<u>Reservoir Description 82 of figure 13</u>

Refer now to figure 22 which illustrates a dialog depicting the Reservoir Description (82) layout. The Reservoir Description 82 is shown in figure 13.

Additional options will include:

- import and display of corner point and block centered geometry
- simple gridding options, e.g., x meter spaced grid
- re-gridding of corner point model to PEBI grid
- aquifer support

<u>PVT Database 84 of figure 13</u>

Refer now to figure 23 which illustrates a dialog depicting the PVT database (84) layout. The PVT database 84 is shown in figure 13.

Additional options will include:

- import of PVT data from existing dataset
- support for more than one PVT region
- compositional and thermal keywords
- region painter

Menu Bar Items

File

- close - closes PVT section
- Import - reads PVT data from existing dataset
- PVTi - runs PVTi
- Save - saves as an Include file

View

- Plot - plots data
- Keywords - displays keywords
- Correlation - displays correlation inputs and plots

Region

- Add - adds a new region

- Edit - edits regions
- Delete - deletes a region

SCAL database 86 of figure 13

Refer now to figure 24 which illustrates a dialog depicting the SCAL database (86) layout. The SCAL database 86 is shown in figure 13.

Additional options will include:

- import of SCAL data from existing dataset
- support for more than one SCAL region
- three phase relative permeability correlation
- region painter

Menu Bar Items

File

- Close - closes SCAL section
- Import - reads SCAL data from existing dataset
- SCAL - runs SCAL program
- Save - saves as Include file

View

- Plot - plots data
- Keywords - displays keywords
- Correlation - displays correlation input and plots

Region

- Add - adds a new region
- Edit - Edits regions
- Delete - deletes a region

Initialization 88 of figure 13

Initialization - The Initialization section consists of a Menu Bar and Icons.

Menu Bar Items

File

- Close - closes initialization section
- Import - reads initialization data from existing dataset
- Save - saves as Include file

Method

- Equilibration
- Enumeration
- Restart

Restart - This will display a panel of the saved restart numbers and dates from which the user can select the appropriate one.

Enumeration - This will display a window allowing input of initial values.

Menu Bar Items

File

- Close - closes window

Options

- Plot - plots data

Equilibration - This will display a window for contact depth input

Menu Bar Items

File

- close - close window

Options
- Plot - plots data
- keywords - displays keywords

Schedule/Production database 92 of figure 13

Refer now to figure 25 which illustrates a dialog depicting the Schedule database (92) layout. The Schedule/Production database 92 is shown in figure 13.

The Schedule window of figure 25 consists of a Menu Bar, Icons, and a display of the current model (case/scenario) representing the model area together with the wells and their group hierarchy.

Menu Bar Items

File
- Close - closes Schedule module
- Schedule - runs Schedule program
- VFPi - runs VFPi program
- Save - saves as Include file

Edit
- Well
- Group - selects appropriate item and displays
- Network - panel for entry/view of data

Group
- Define - defines new group

Time

- Event times - defines event times

Control

- tuning - sets tuning control for whole run
- Timestep - defines timesteps

Output

The output window consists of a Menu Bar and Icons. The main display area is blank.

Menu Bar Items

File

- Close - closes output section
- Import - import from existing dataset
- Save - saves as Include file

Vector

- Field
- Well
- Group - selects appropriate item for output
- Regions

Multiple Scenarios

The multiple scenarios window consists of a Menu Bar and Icons. The main display area is blank. This section will allow the user to easily specify a number of realizations to be run on this case/scenario. These realizations will be specified in an engineering terminology, e.g., poro/perm relationship, well rates, different PVT data, etc. This will ensure that the Grid Geometry of the model cannot be changed and therefore the runs can be compared.

Run Manager 46c3 of figure11

Refer now to figure 26 which illustrates a workflow or functional block diagram illustrating the function of the Run Manager 46c3 of figure 11.

The functional block diagram of the Run Manager 46c3, which is shown in figure 26, is duplicated below as follows:

Run Model - block 156

- Simulation Model - block 158
    - Submission to:
        - platform of choice - block 162
        - Queuing System - block 162
- Network Analysis (based on VFP tables) - block 160
    - rate data from:
        - simulation run - block 164
        - constant PI - block 164
        - decline curve - block 164

Layout

The "Janus" program will form the basis of the Run Manager 46c3 within the Eclipse Office software 46c. Currently, "Janus" submits, controls and monitors multiple simulator runs through the PVM interface.

Refer now to figure 27 which illustrates the Run Manager 46c3 window. Figure 27 illustrates a view of "Janus", which forms the basis of the Run Manager. The Run Manager 46c3 window of figure 27 consists of a menu bar and icons.

Results Viewer 44e1 of figure 11

Refer now to figure 28 for the workflow or functional block diagram of the Results viewer 44e1 of figure 11. The functional block diagram of the results viewer 44e1 of figure 28 is duplicated below, as follows:

- ☐ Run Manager (monitor and control) - block 166
- ☐ Results viewer (real time updates) - high quality hardcopy - block 168
  - ☐ Vector data - block 170
    - ☐ predefined layouts for main plots
      - ☐ ability to plot anything against anything including observed data (RFT, PLT)
  - ☐ Solution data - block 172
    - ☐ 2D areal - 2D cross section
      - ☐ well locations/tracks
        - ☐ contours and cell based color displays
          - ☐ ability for derived quantities
    - ☐ optional 3D display
  - ☐ Run controller (as Janus) - block 174
    - ☐ STOP, PAUSE
    - ☐ Advance and write RESTART

The results viewer window (screen display) consists of a Menu Bar, Post Processor pushbuttons, Icons, and a display of the current model (case/scenario) representing the model area together with the wells. This will be blank if a no case/scenario is selected.

<u>Report Generator 44e2 of figure 11</u>

Refer now to figure 29 for the workflow or functional block diagram of the Report Generator 44e2 of figure 11. The functional block diagram of the report generator 44e2 of figure 29 is duplicated below, as follows:

Report Generator - block 176

- ☐ Template based (removes fixed simulator print file)

- Collates data AND plots from any (or all) runs within a project
- Flexible to allow tabular output to be generated for post processing (e.g. economic analysis)
    - provide calculator scripts to conduct common analyses
- Full support for 'local' printer drivers (e.g. MS windows)

Layout

The report generator window consists of a Menu Bar, Icons, and a display of the current model (case/scenario) representing the model area together with the wells. This will be blank if a no case/scenario is selected.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

WE CLAIM:

1. A simulation system responsive to a plurality of sets of input data for simulating an earth formation located in the vicinity of an oilfield reservoir, generating a set of simulation results in response to the simulation, and displaying the set of simulation results, comprising:

case manager means for organizing and managing the plurality of sets of input data being used by the simulation system, said case manager means including a plurality of case scenarios organized in a tree-like structure, some of said case scenarios being subsets of other of said case scenarios in the tree-like structure, an operator selecting one or more of the case scenarios in the case manager;

case builder means for receiving said one or more of the case scenarios selected by the operator, editing or changing a set of data disposed within the selected case scenarios in response to editing actions taken by the operator, and, responsive thereto, generating a set of edited case scenarios;

run manager means responding to the set of edited case scenarios from the case builder means for submitting the edited case scenarios to a simulator, the simulator responding to the edited case scenarios from the run manager means by executing and thereby generating the set of simulation results, the set of simulation results from the simulator being stored in a results file,

the run manager means receiving the set of simulation results from the results file in addition to the set of edited case scenarios from the case builder means and enabling the operator to monitor and compare the set of simulation results received from the results file with the set of edited case scenarios received from the case builder means;

results viewer means for displaying the set of simulation results generated by the simulator, the results viewer displaying the set of simulation results and any instantaneous changes being made to the set of simulation results at any point in time; and

report generator means for generating one or more reports which record the set of simulation results.

ABSTRACT OF THE DISCLOSURE

A simulation system is responsive to a plurality of sets of input data for simulating an earth formation located in the vicinity of an oilfield reservoir, generating a set of simulation results in response to the simulation, and displaying the set of simulation results. The simulation system includes a case manager adapted for organizing and managing the plurality of sets of input data being used by the simulation system. The case manager includes a plurality of case scenarios organized in a tree-like structure, some case scenarios being subsets of other case scenarios in the tree-like structure, an operator selecting one or more of the case scenarios in the case manager. A case builder receives the one or more of the case scenarios selected by the operator, edits and/or changes a set of data disposed within the selected case scenarios in response to editing actions taken by the operator, and, responsive thereto, generates a set of edited case scenarios. A run manager responds to the set of edited case scenarios from the case builder by submitting the edited case scenarios to a simulator, the simulator responding to the edited case scenarios from the run manager by executing and thereby generating a set of simulation results, the set of simulation results from the simulator being stored in a results file. The run manager receives the set of simulation results from the results file in addition to the set of edited case scenarios from the case builder thereby enabling an operator to monitor and compare via the run manager the set of simulation results received from the results file with the set of edited case scenarios received from the case builder. A results viewer will display the set of simulation results generated by the simulator and a report generator will generate one or more reports which record the set of simulation results. The results viewer displays not only the set of simulation results but also any instantaneous changes being made to the set of simulation results at any point in time.

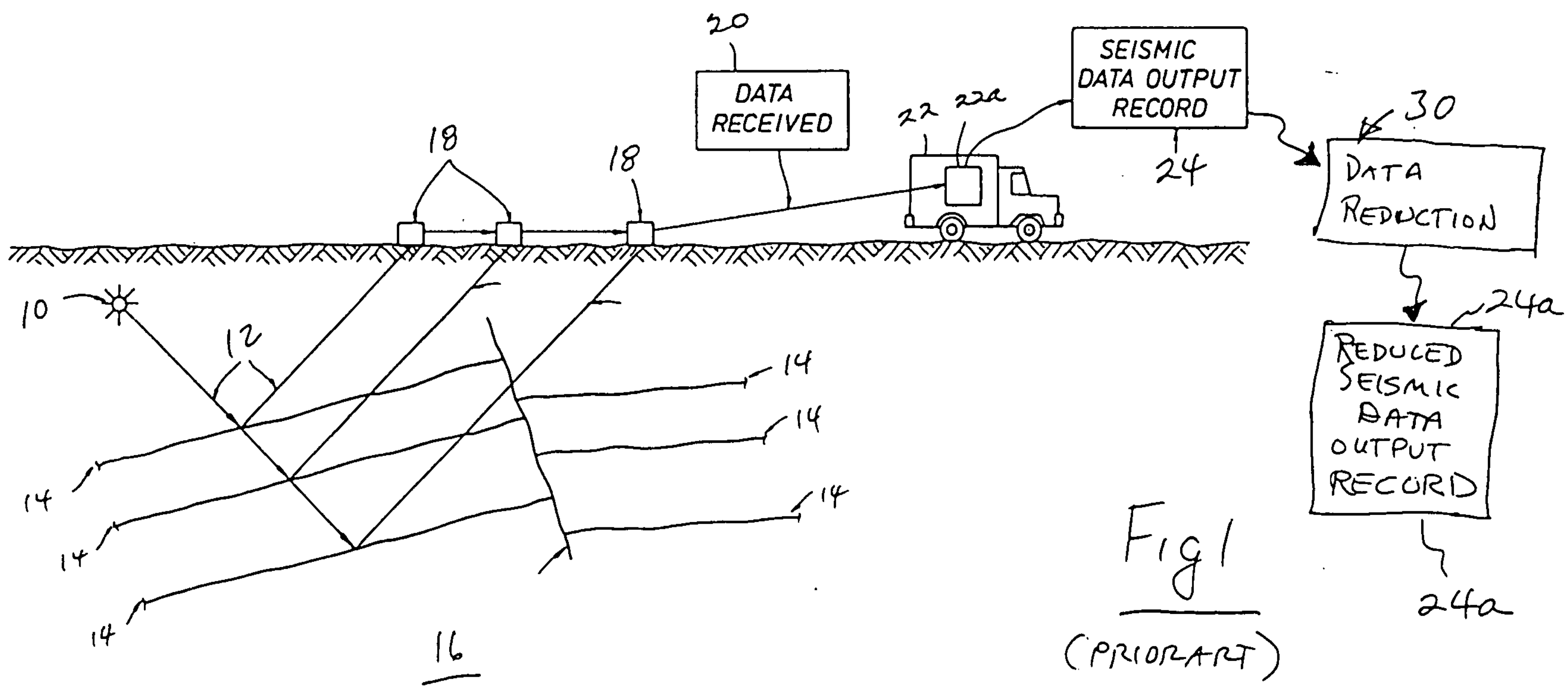


Fig 1
(PRIOR ART)

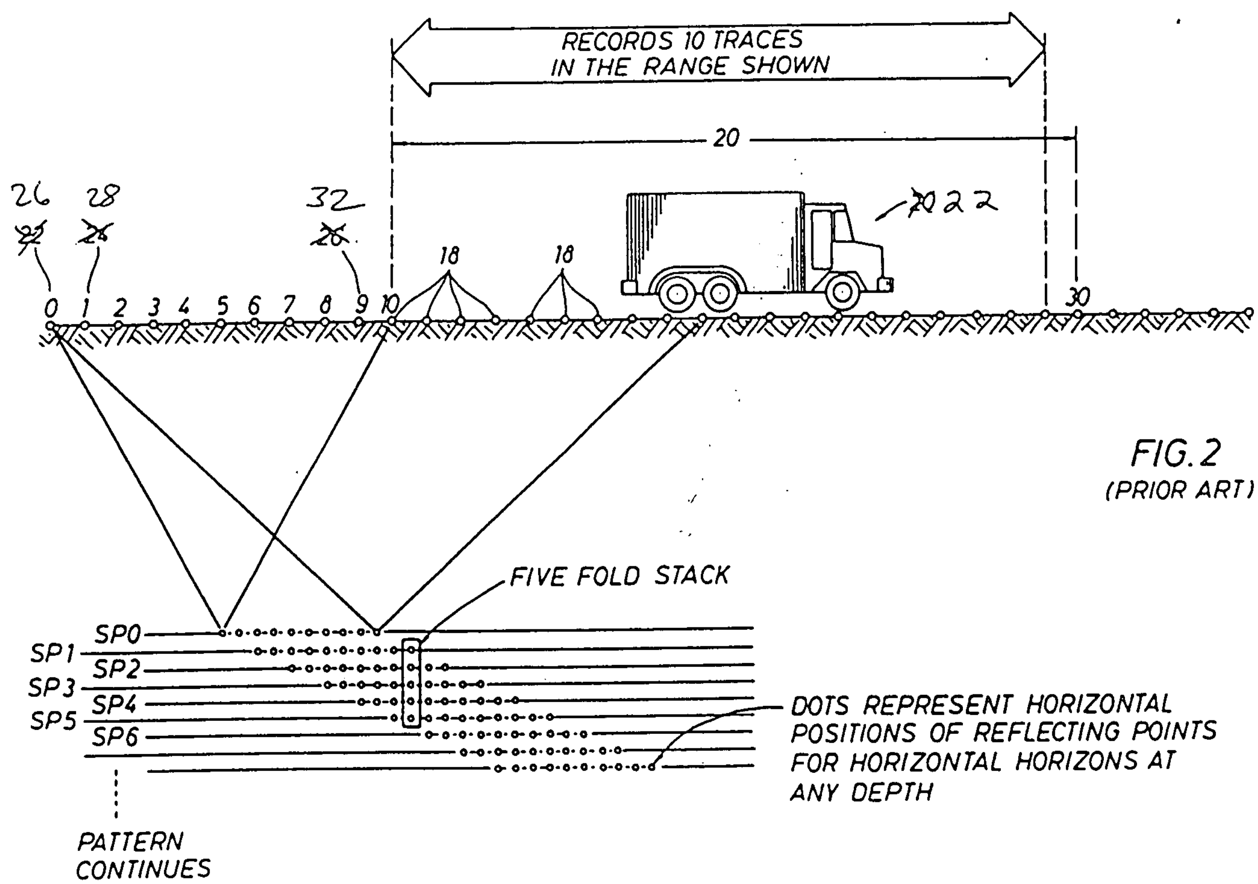


FIG. 2
(PRIOR ART)

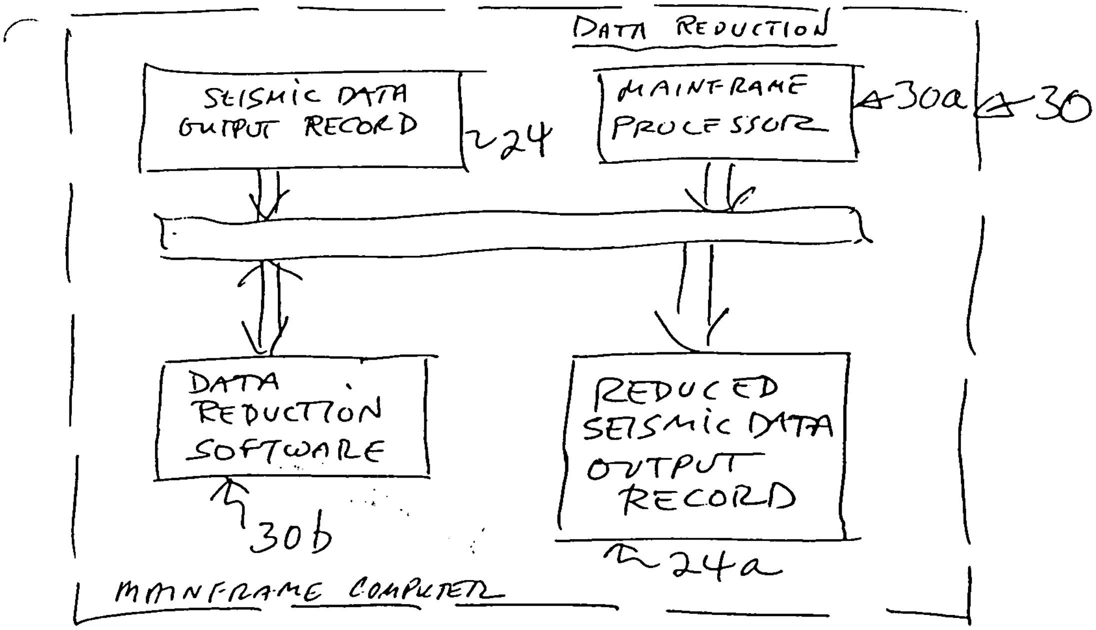
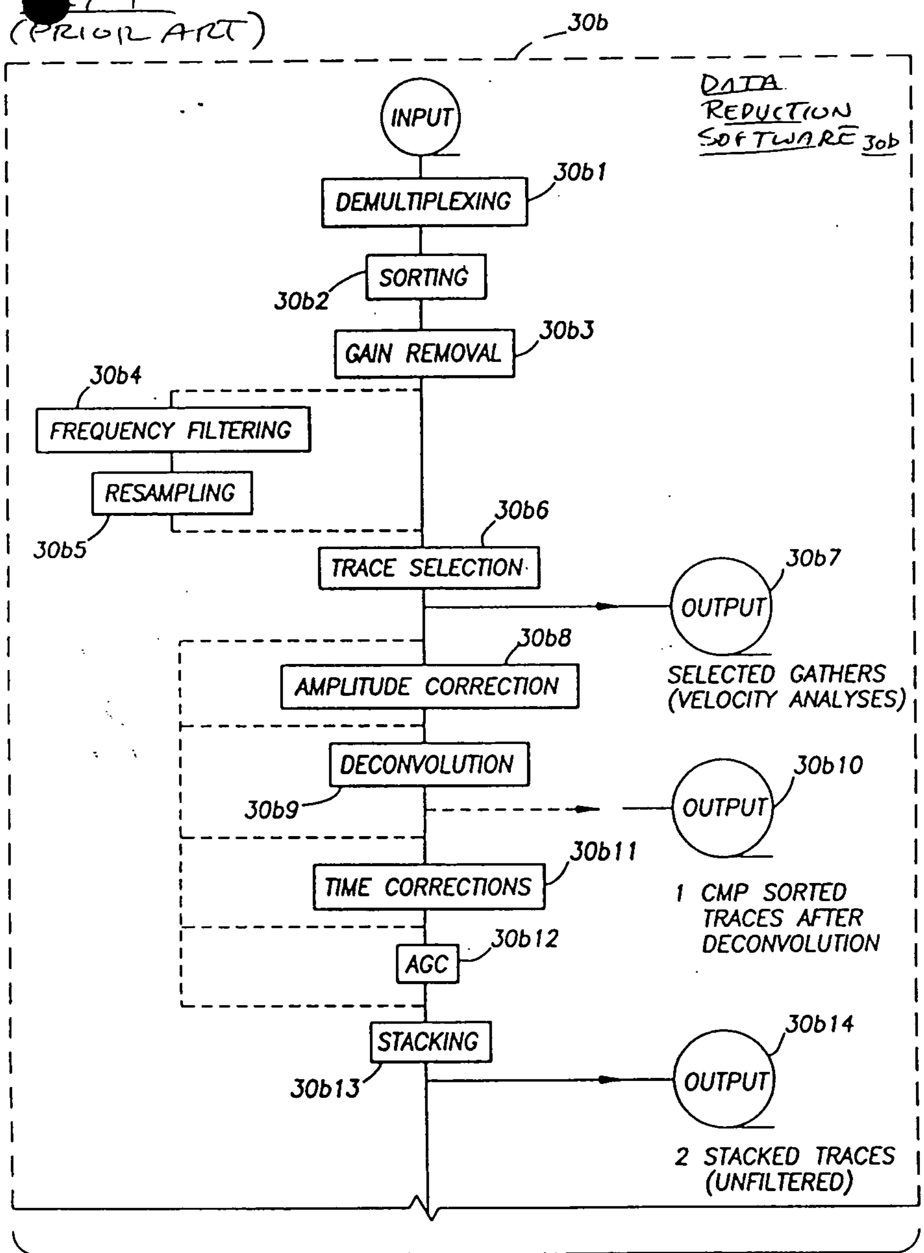


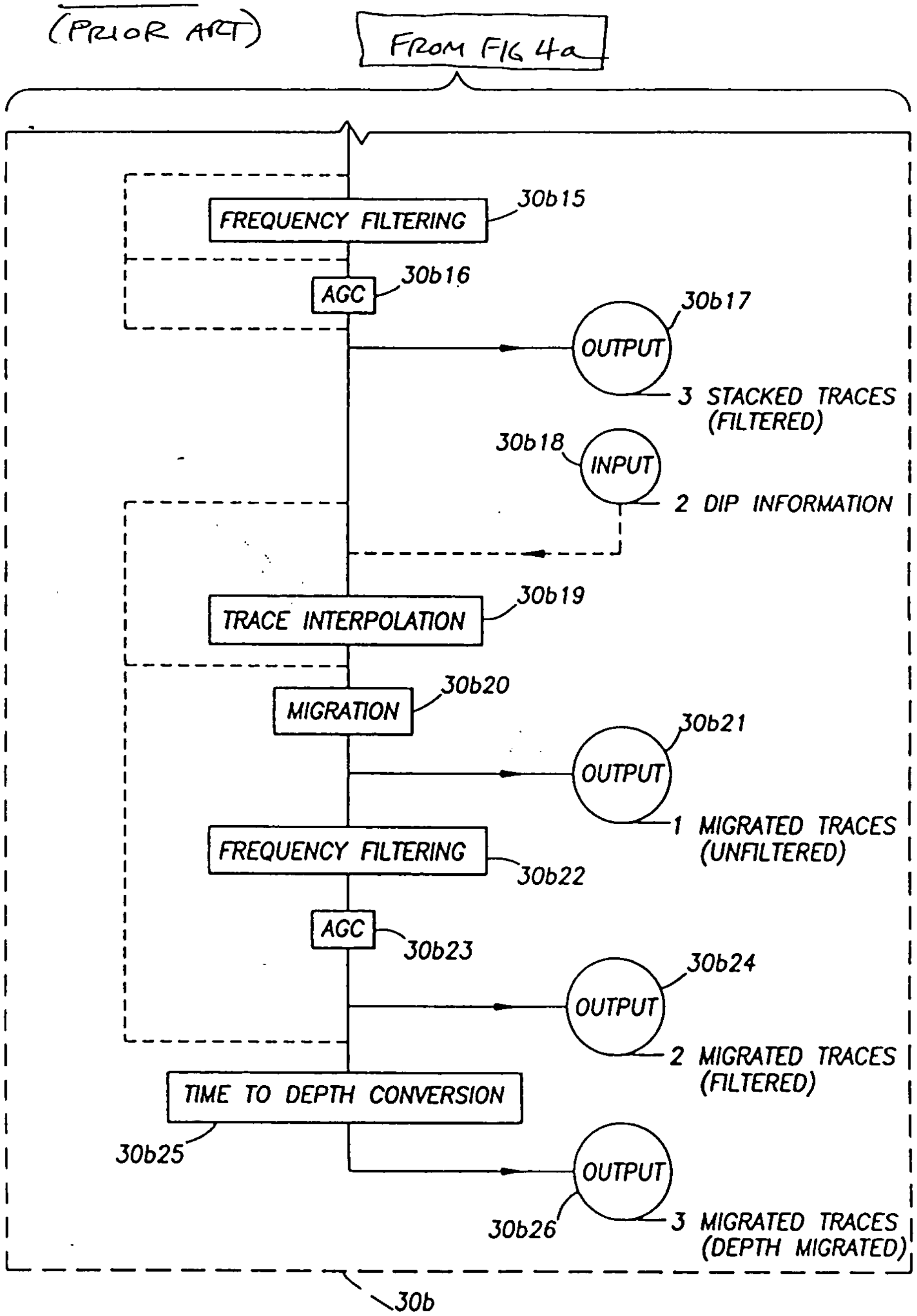
Fig 3
(PRIOR ART)

FIG 4a
(PRIOR ART)



To FIG 4b

FIG 4b
(PRIOR ART)



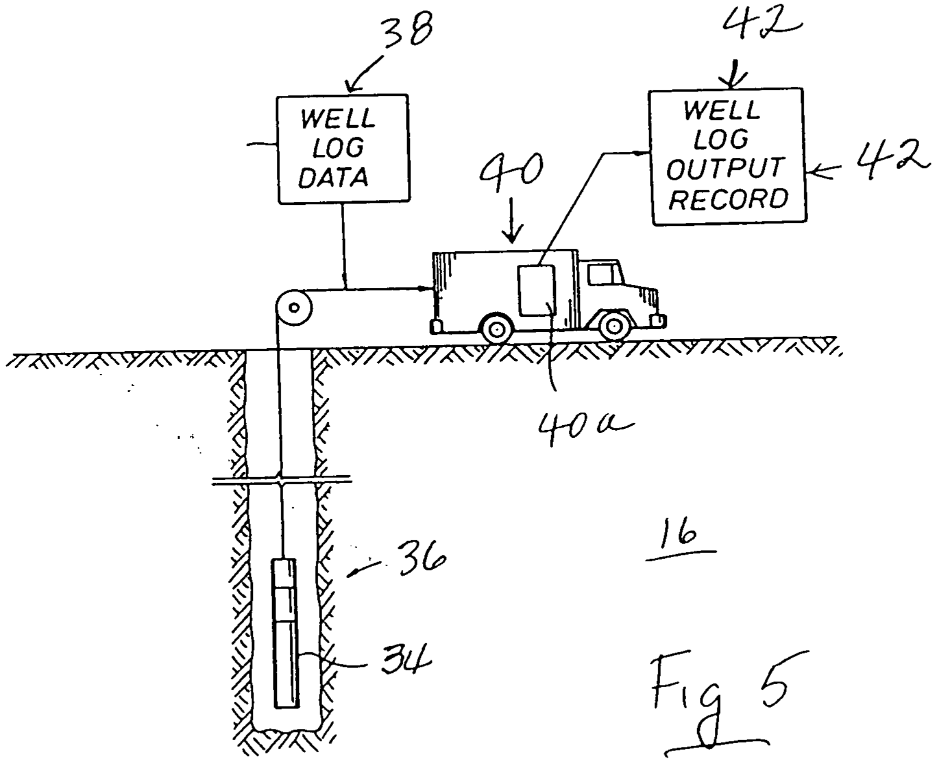


Fig 5

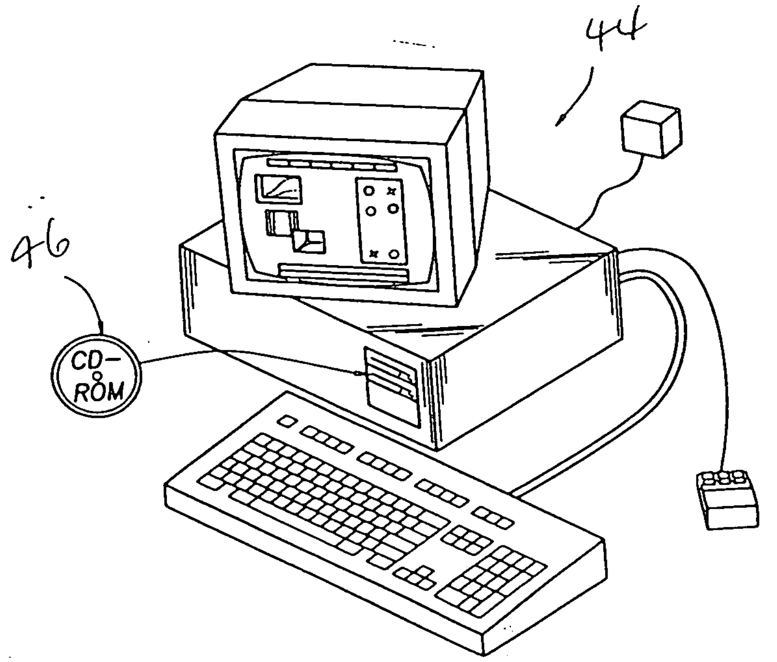

44
46
CD-ROM

Fig 6

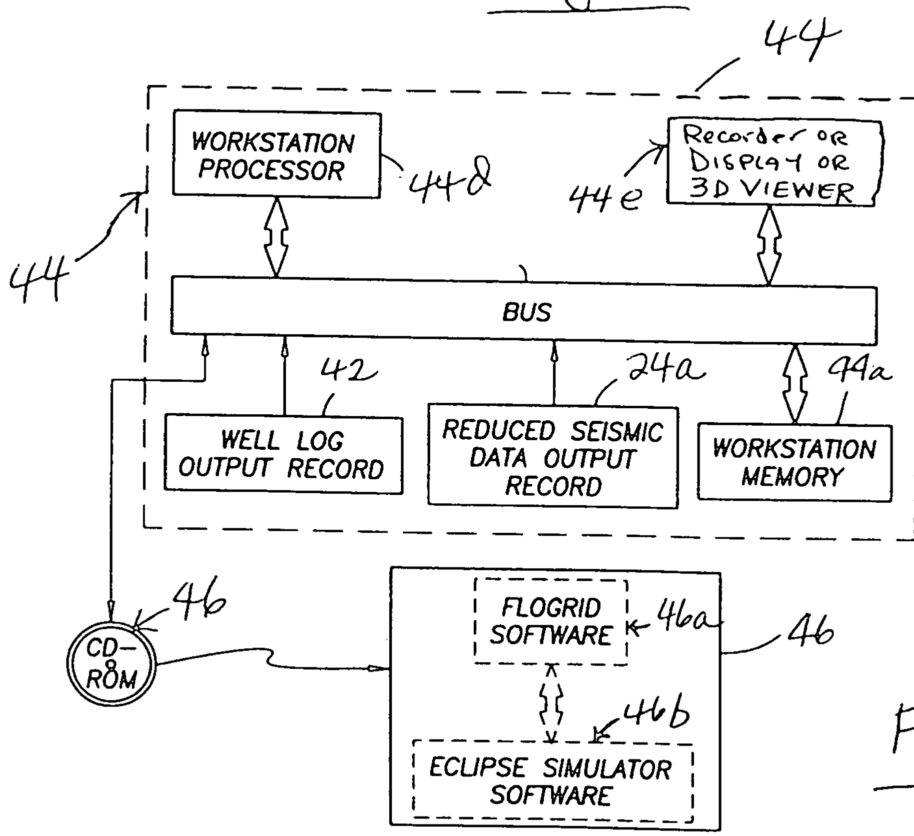

44
WORKSTATION PROCESSOR
44d
44e
Recorder or Display or 3D Viewer
44
BUS
42
24a
44a
WELL LOG OUTPUT RECORD
REDUCED SEISMIC DATA OUTPUT RECORD
WORKSTATION MEMORY
46
CD-ROM
FLOGRID SOFTWARE
46a
46
46b
ECLIPSE SIMULATOR SOFTWARE

Fig 7

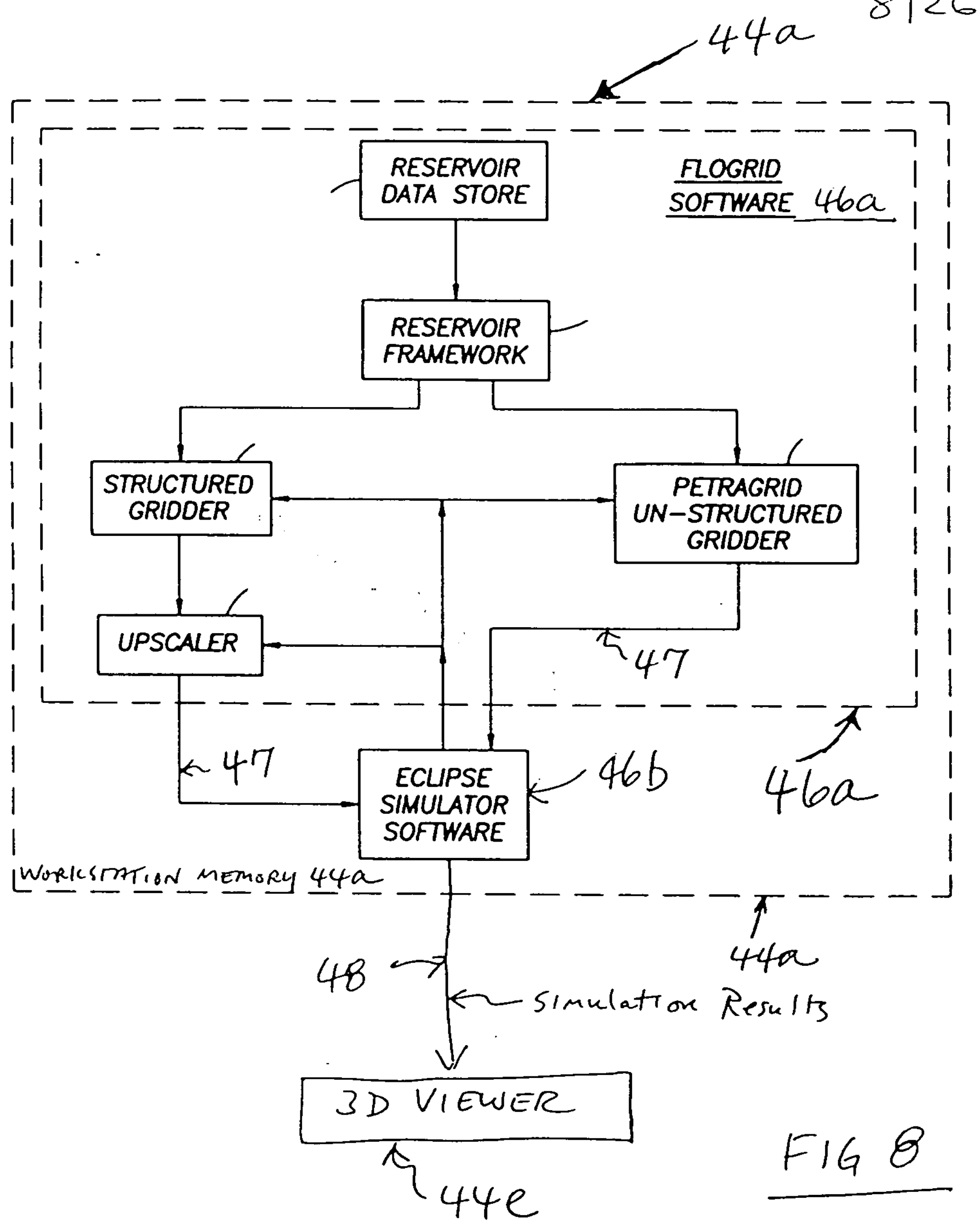

44a
RESERVOIR DATA STORE
FLOGRID SOFTWARE 46a
RESERVOIR FRAMEWORK
STRUCTURED GRIDDER
PETRAGRID UN-STRUCTURED GRIDDER
UPSCALER
47
47
ECLIPSE SIMULATOR SOFTWARE
46b
46a
WORKSTATION MEMORY 44a
44a
48
Simulation Results
3D VIEWER
44e

FIG 8

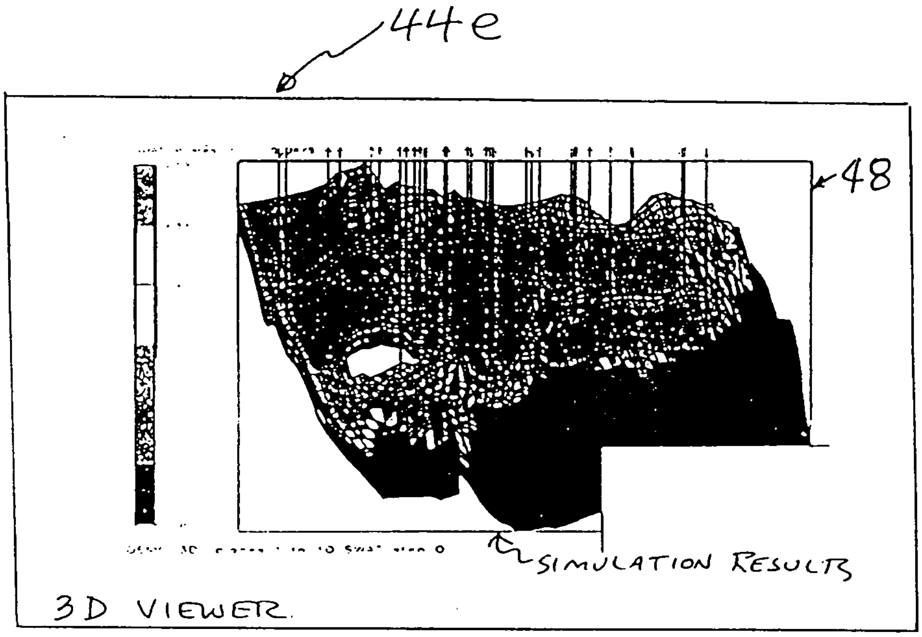


FIG 9

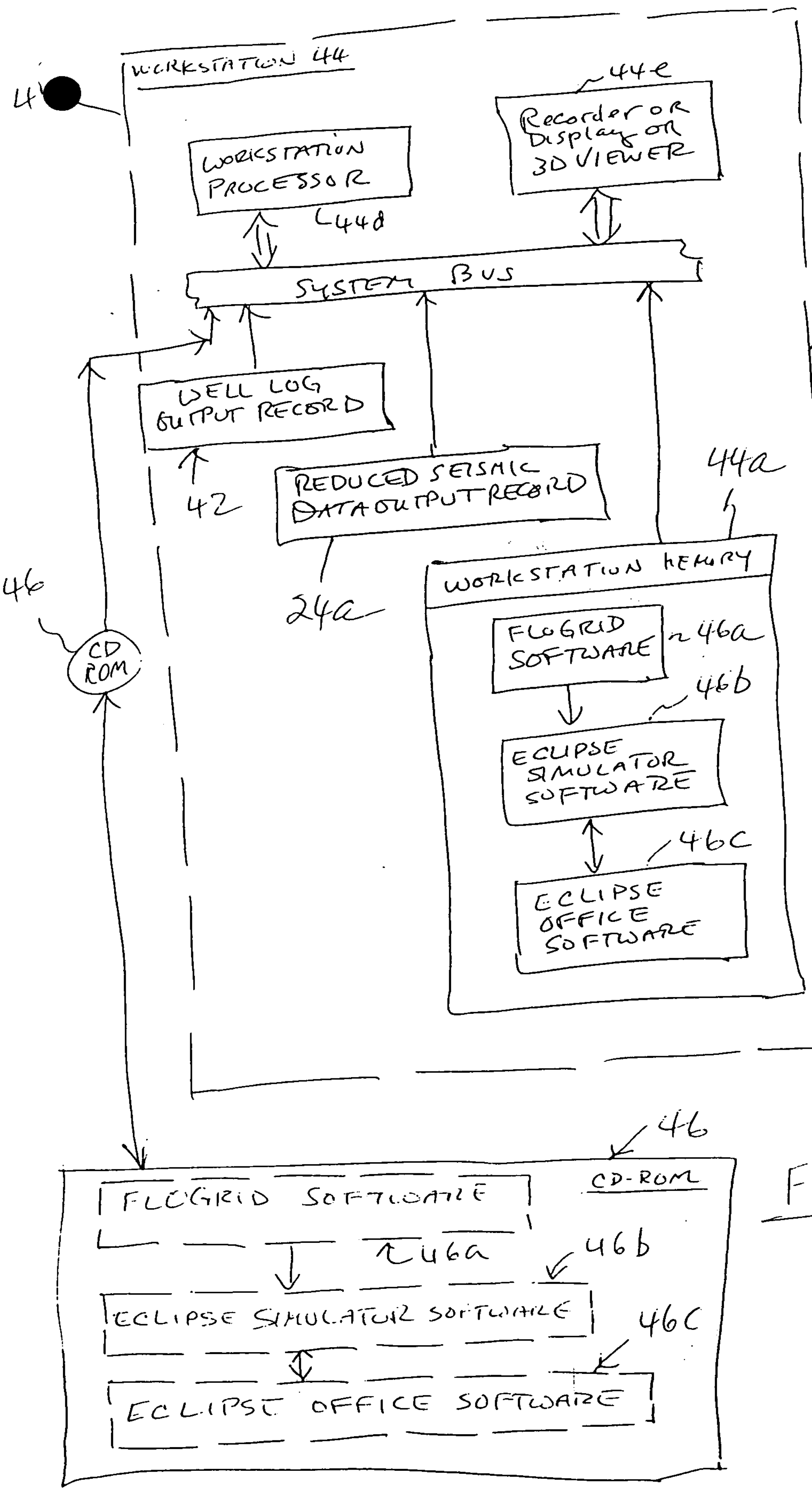

WORKSTATION 44
4
44e
Recorder or Display or 3D VIEWER
WORKSTATION PROCESSOR
44d
SYSTEM BUS
44
WELL LOG OUTPUT RECORD
42
REDUCED SEISMIC DATA OUTPUT RECORD
24a
44a
WORKSTATION MEMORY
FLOGRID SOFTWARE
46a
46b
ECLIPSE SIMULATOR SOFTWARE
46c
ECLIPSE OFFICE SOFTWARE
46
CD ROM
46
CD-ROM
FLOGRID SOFTWARE
46a
46b
ECLIPSE SIMULATOR SOFTWARE
46C
ECLIPSE OFFICE SOFTWARE

FIG 9a

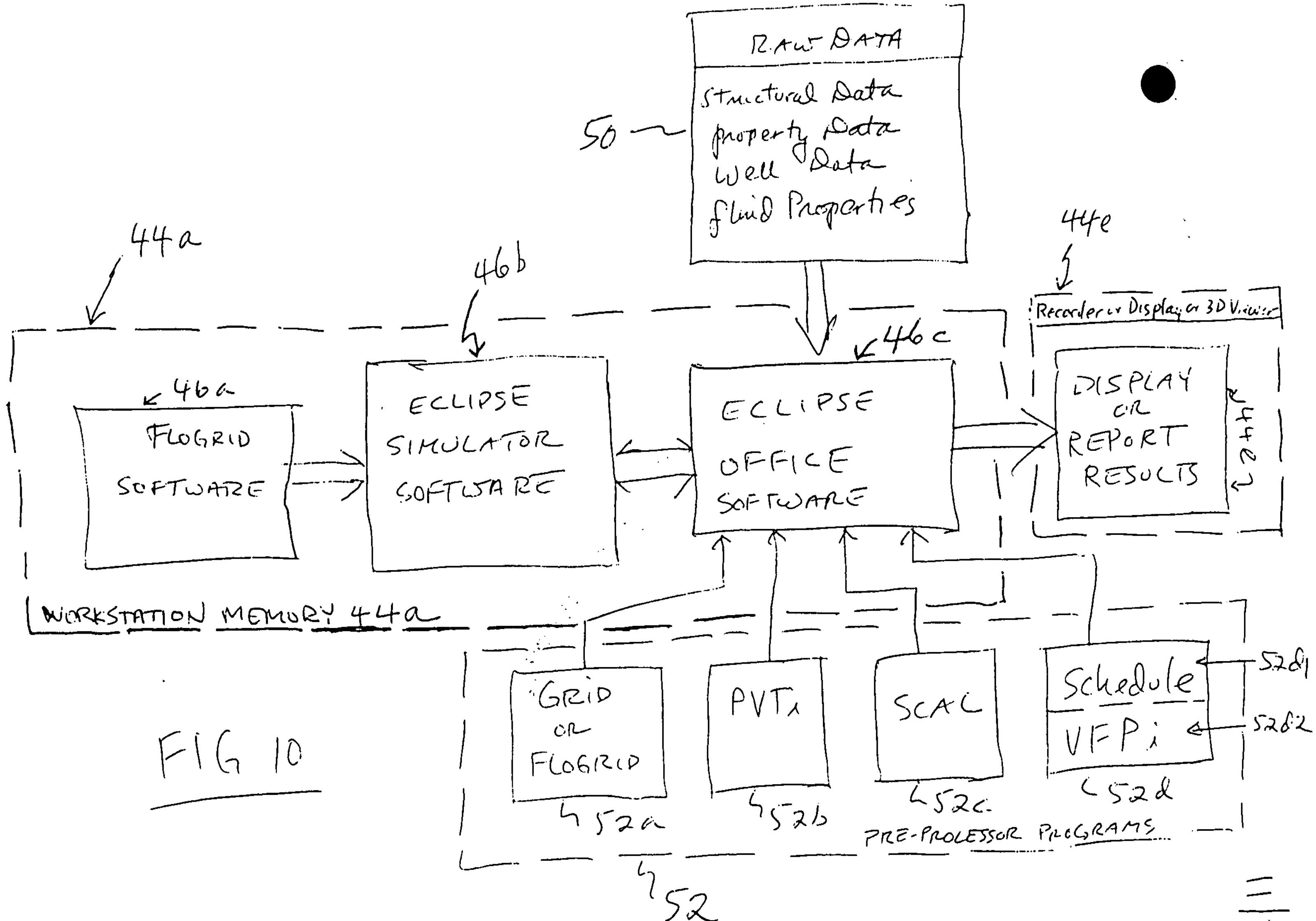

RAW DATA
Structural Data
property Data
Well Data
fluid Properties
50
44a
46b
46a
FLOGRID SOFTWARE
ECLIPSE SIMULATOR SOFTWARE
46c
ECLIPSE OFFICE SOFTWARE
44e
Recorder or Display or 3D Viewer
DISPLAY OR REPORT RESULTS
44e
WORKSTATION MEMORY 44a
GRID OR FLOGRID
PVTx
SCAL
Schedule
VFPi
52d1
52d2
52a
52b
52c
52d
PRE-PROCESSOR PROGRAMS
52

FIG 10

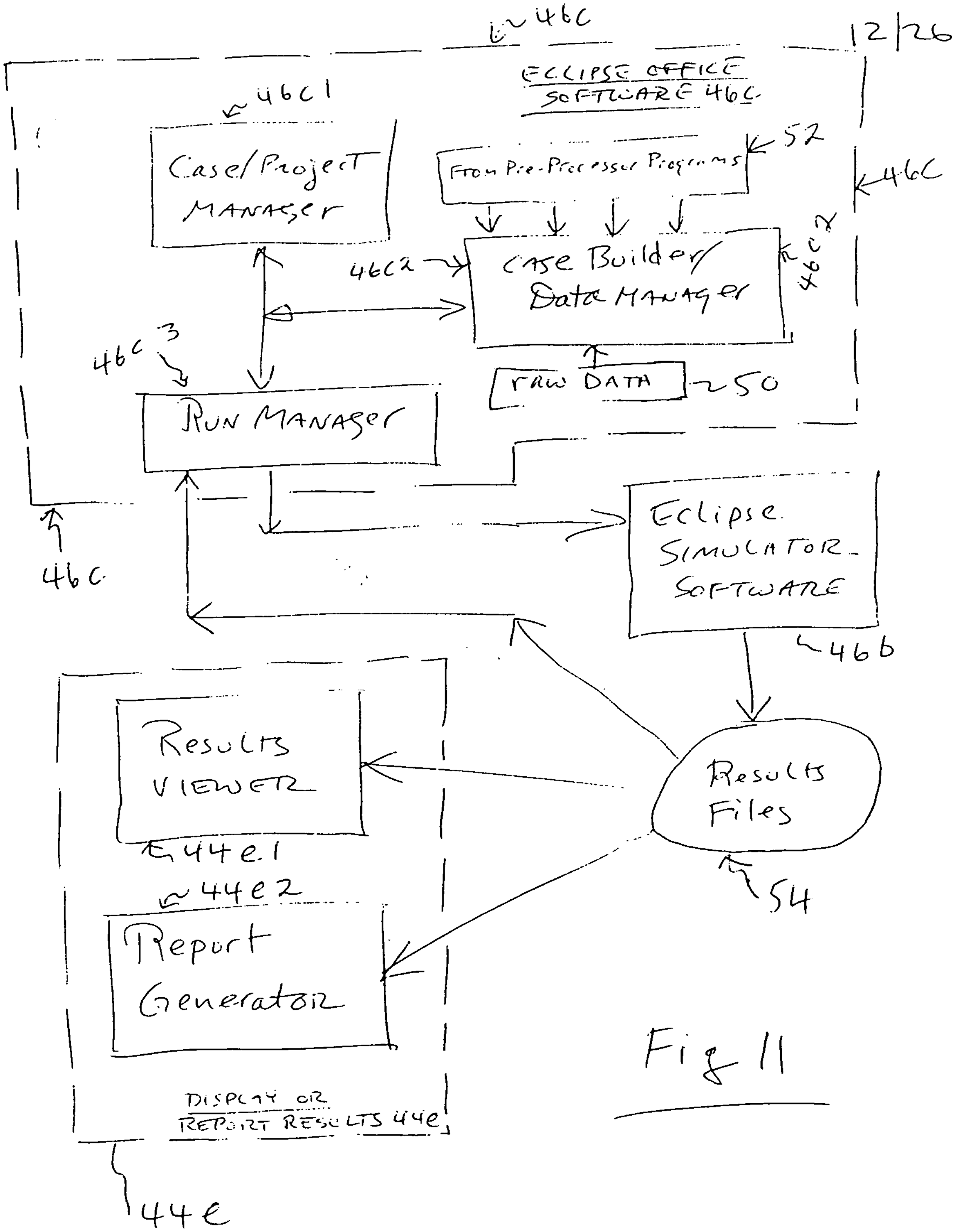

46c
ECLIPSE OFFICE SOFTWARE 46c
46c1
Case/Project Manager
52
From Pre-Processor Programs
46c
46c2
Case Builder/ Data Manager
46c2
46c3
Run Manager
Raw Data
250
46c
Eclipse Simulator Software
46b
Results Viewer
44e.1
44e2
Report Generator
Results Files
54
Display or Report Results 44e
44e

Fig 11

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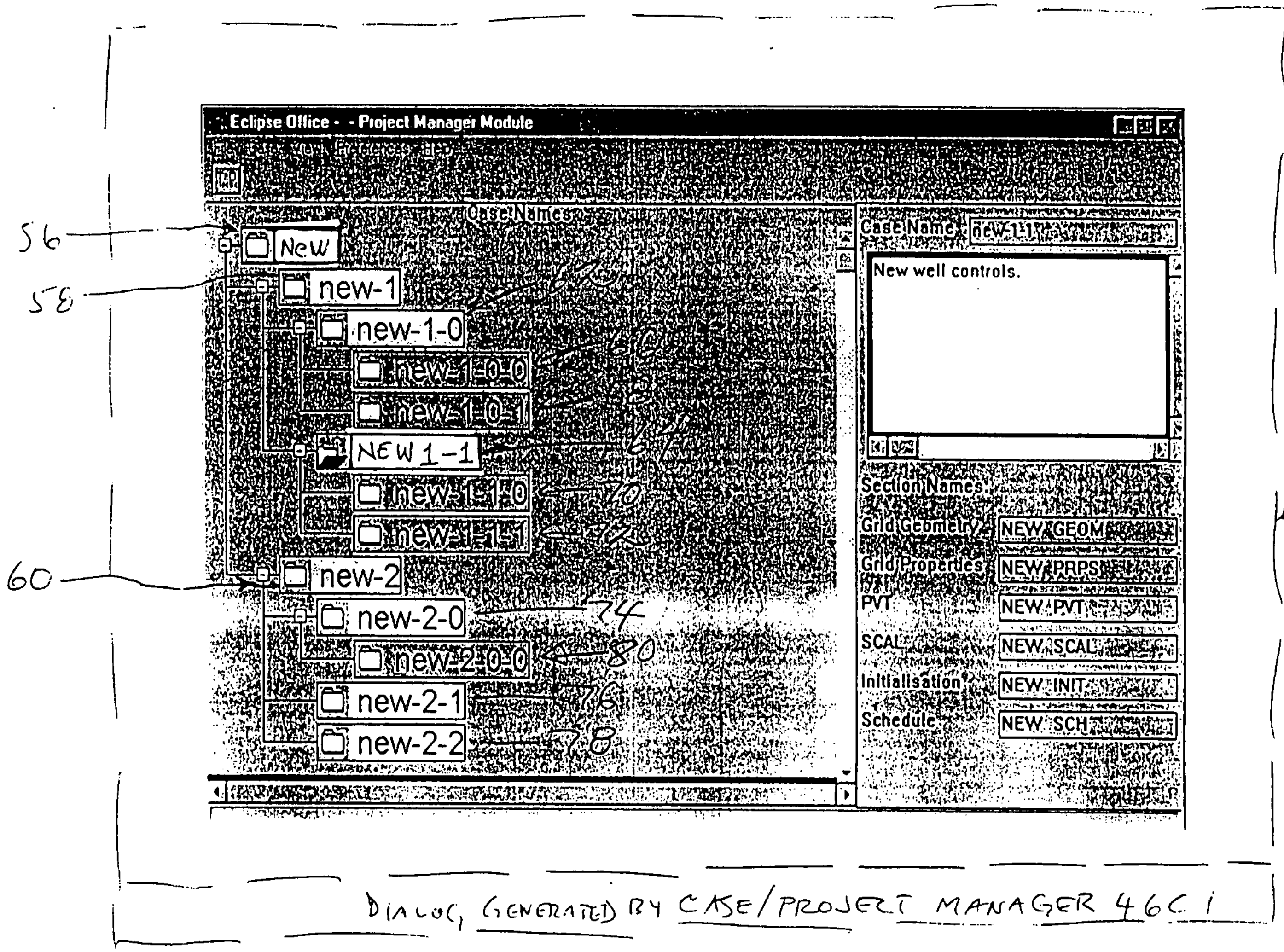

DIALOG GENERATED BY CASE/PROJECT MANAGER 46C1

FIG 12

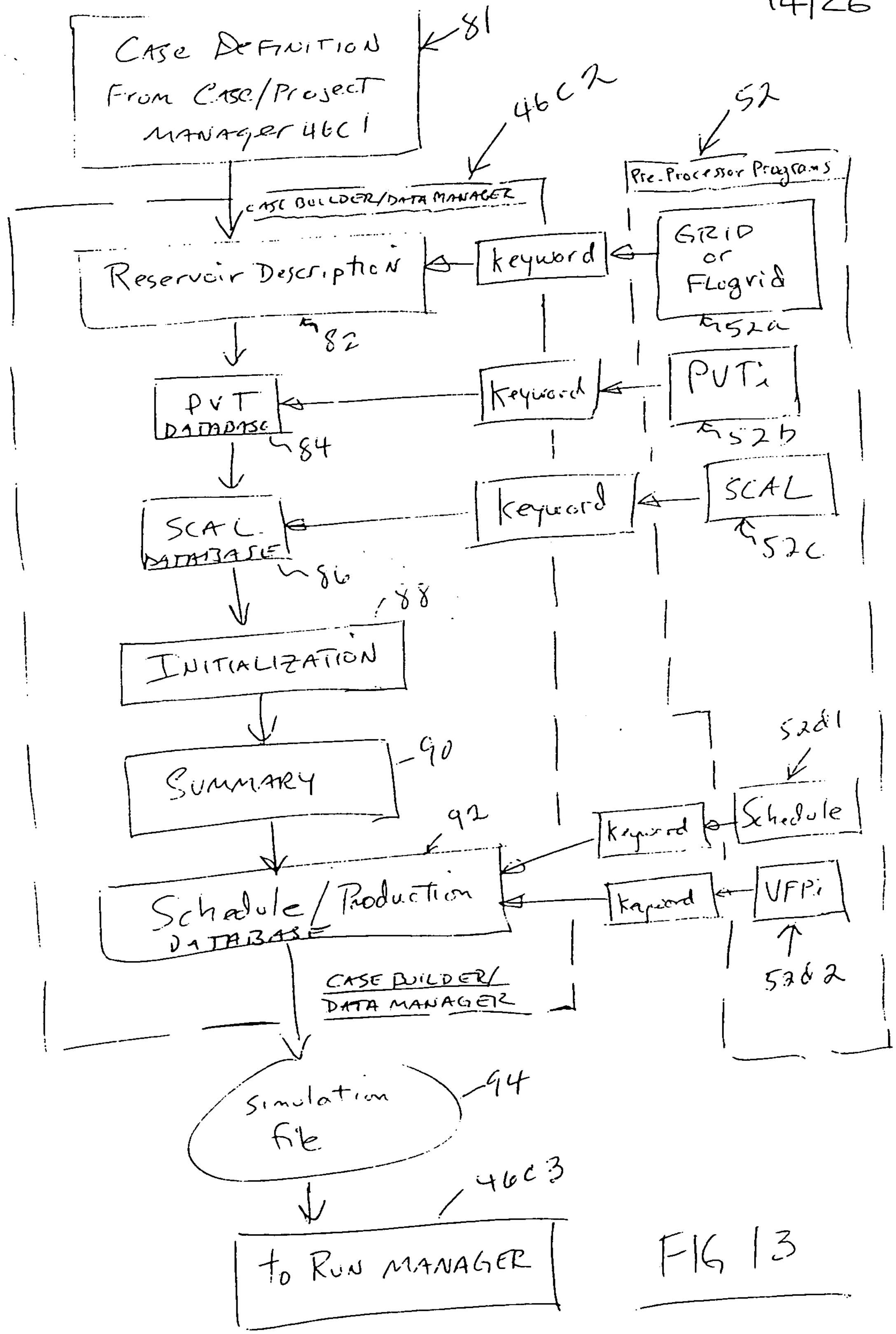
CASE DEFINITION From CASE/PROJECT MANAGER 46C1
81
46C2
52
CASE BUILDER/DATA MANAGER
Pre-Processor Programs
Reservoir Description
82
keyword
GRID or FLOGRID
52a
PVT DATABASE
84
Keyword
PVTi
52b
SCAL DATABASE
86
keyword
SCAL
52c
88
INITIALIZATION
SUMMARY
90
52d1
Schedule
92
Keyword
Schedule/Production DATABASE
Keyword
VFPi
52d2
CASE BUILDER/ DATA MANAGER
Simulation file
94
46C3
to RUN MANAGER

FIG 13

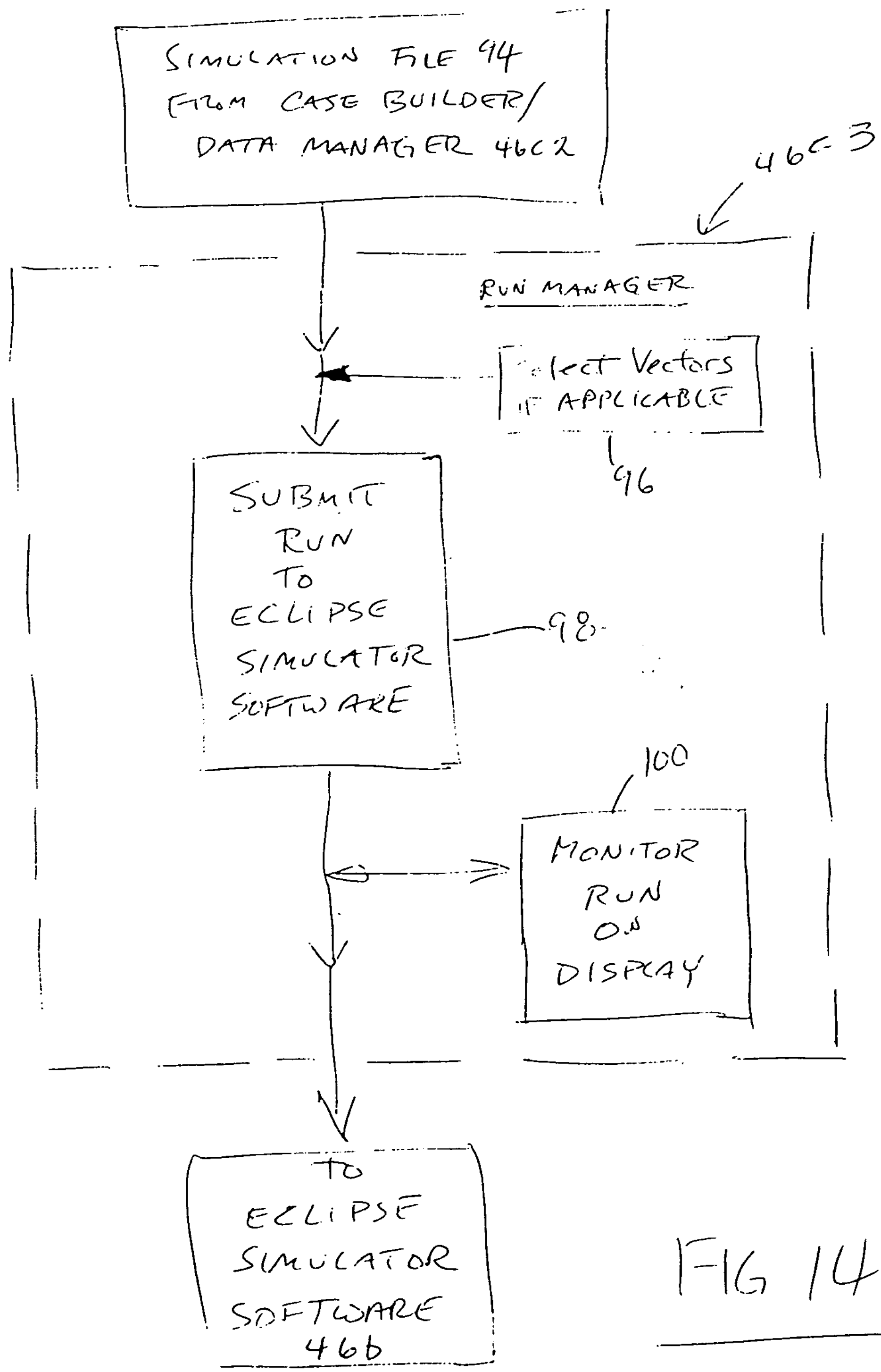
SIMULATION FILE 94
FROM CASE BUILDER/
DATA MANAGER 46c2
46c-3
RUN MANAGER
Select Vectors
IF APPLICABLE
96
SUBMIT
RUN
TO
ECLIPSE
SIMULATOR
SOFTWARE
98
100
MONITOR
RUN
ON
DISPLAY
TO
ECLIPSE
SIMULATOR
SOFTWARE
46b

FIG 14

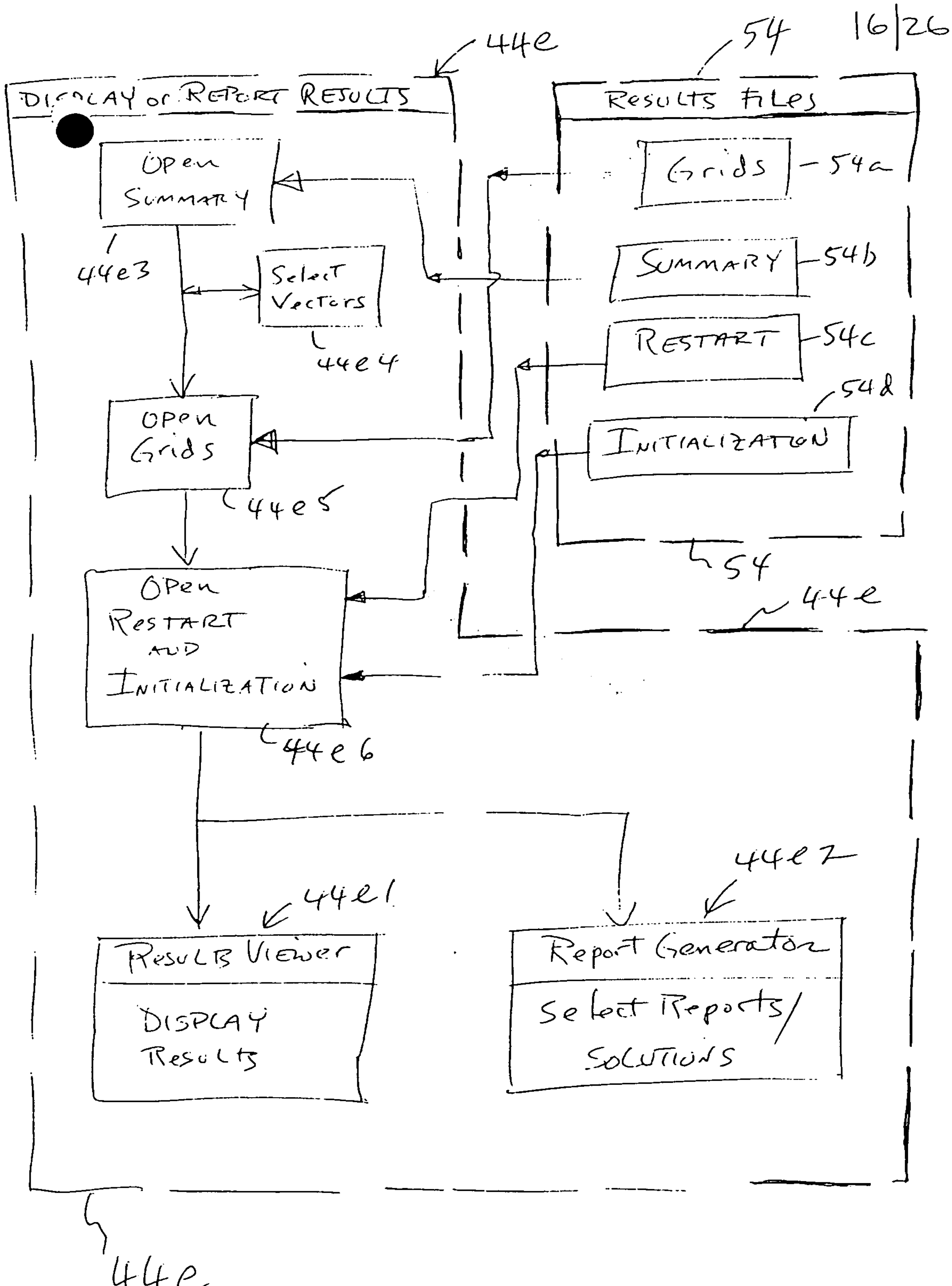
44e
54
DISPLAY or REPORT RESULTS
RESULTS FILES
Open Summary
44e3
Select Vectors
44e4
Grids
54a
SUMMARY
54b
RESTART
54c
54d
INITIALIZATION
Open Grids
44e5
54
44e
Open Restart and Initialization
44e6
44e1
44e7
Results Viewer
DISPLAY Results
Report Generator
Select Reports/ SOLUTIONS
44e

FIG 15

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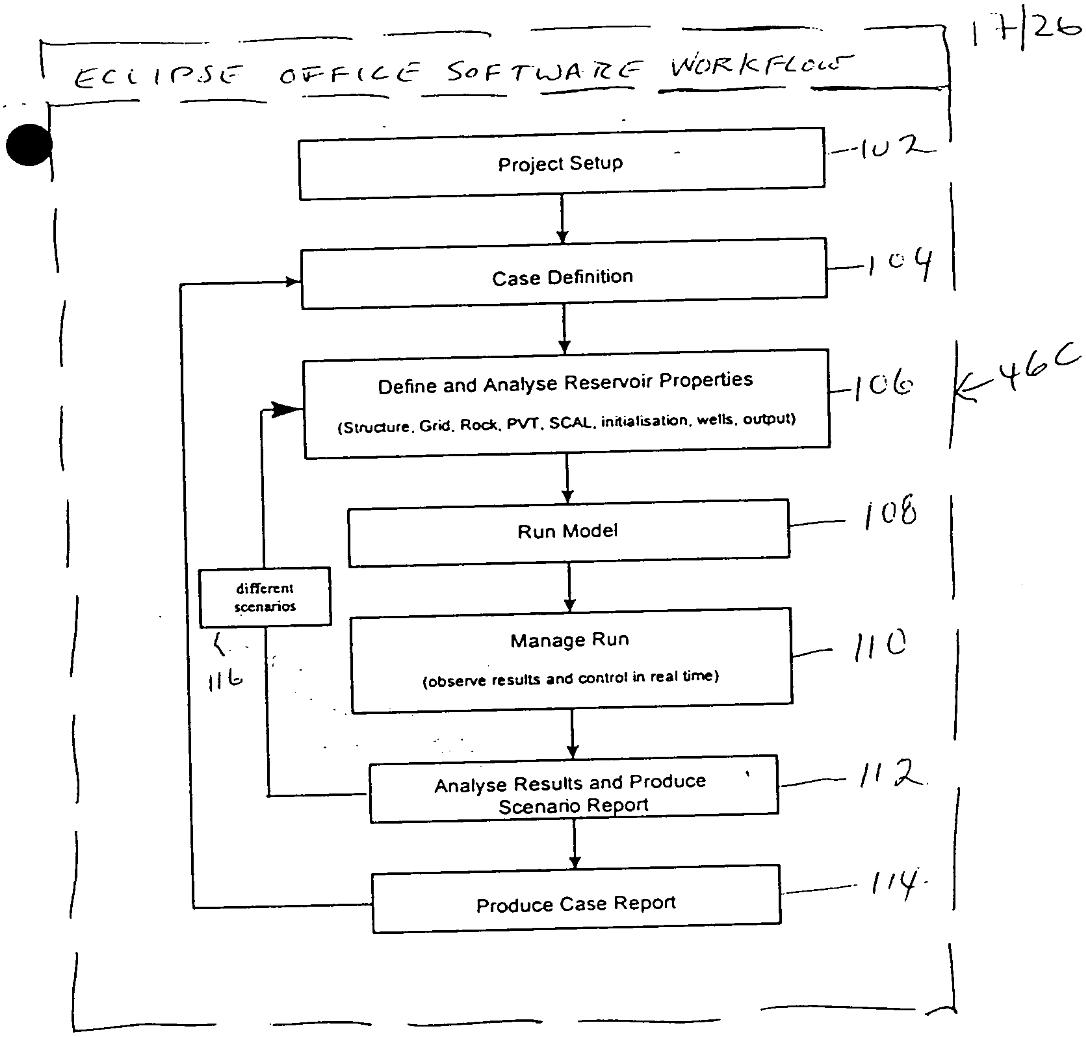
ECLIPSE OFFICE SOFTWARE WORKFLOW
Project Setup
102
Case Definition
104
Define and Analyse Reservoir Properties
(Structure, Grid, Rock, PVT, SCAL, initialisation, wells, output)
106
46C
Run Model
108
different scenarios
116
Manage Run
(observe results and control in real time)
110
Analyse Results and Produce Scenario Report
112
Produce Case Report
114

FIG 16

DIALOG DEPICTING ECLIPSE OFFICE APPLICATION LAYOUT

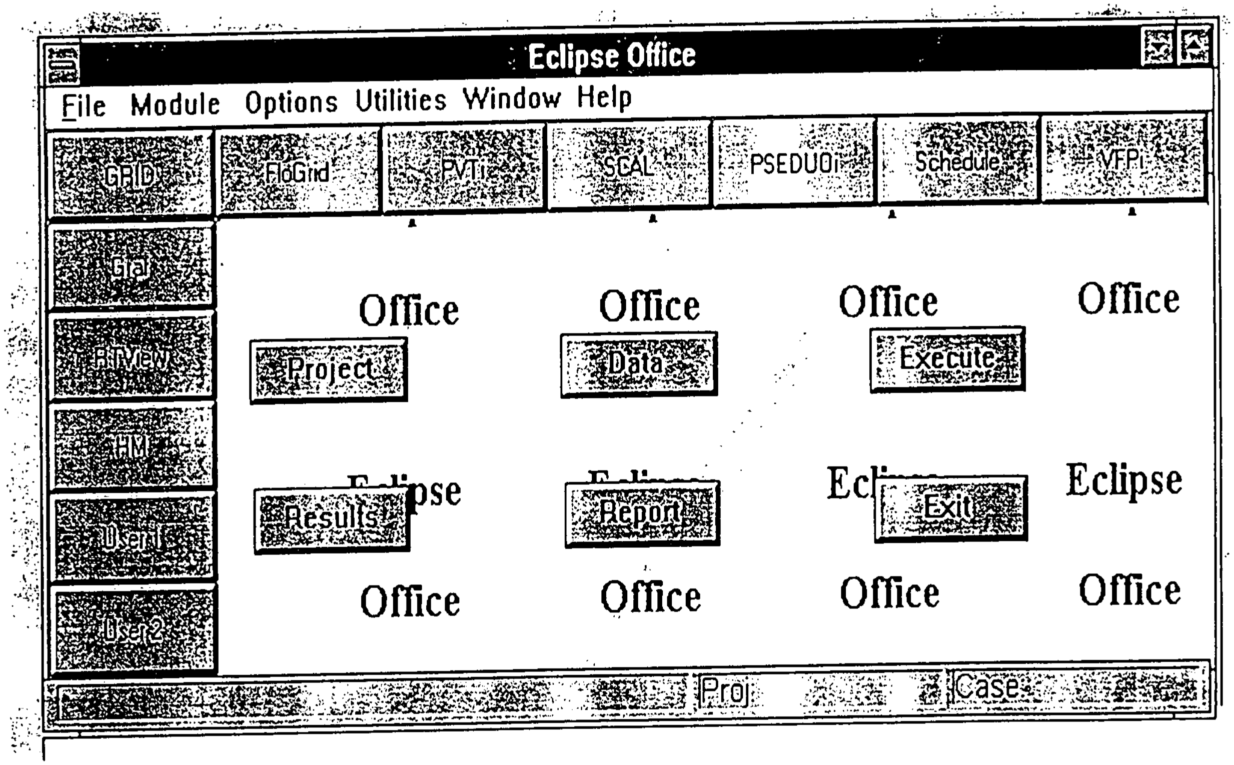

FIG 17

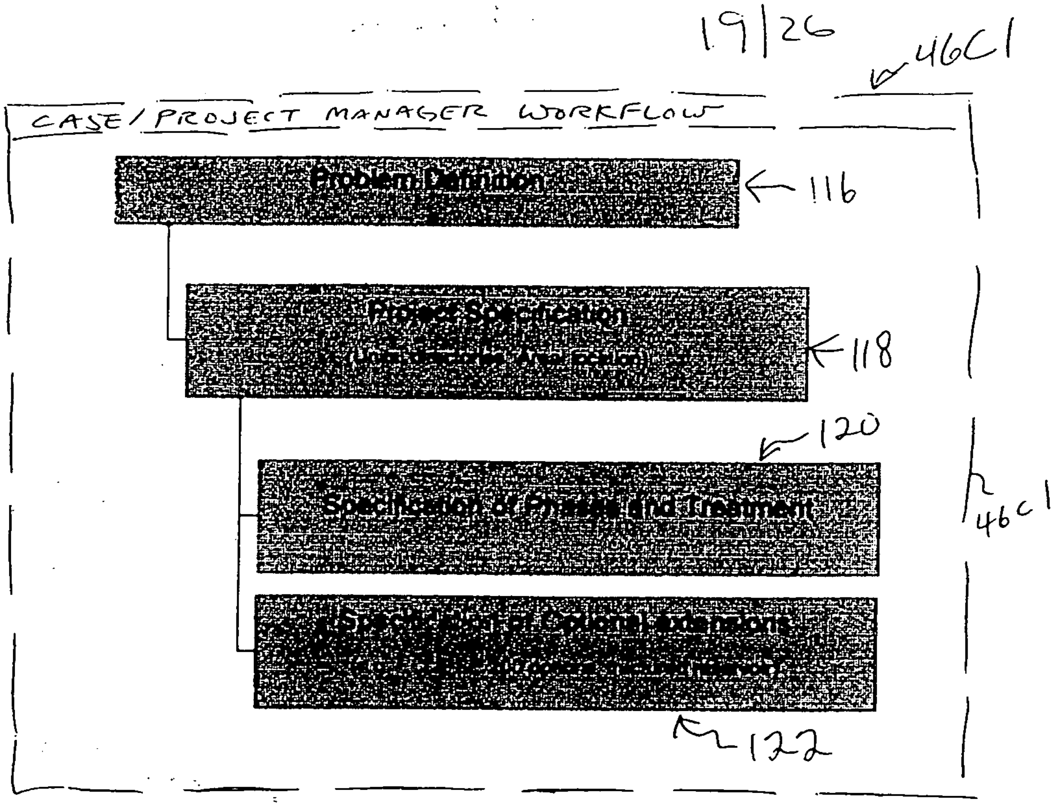
46C1
CASE/PROJECT MANAGER WORKFLOW
Problem Definition
116
Project Specification
118
120
Specification of Phases and Treatment
46C1
Specification of Optional extensions
122

FIG 18

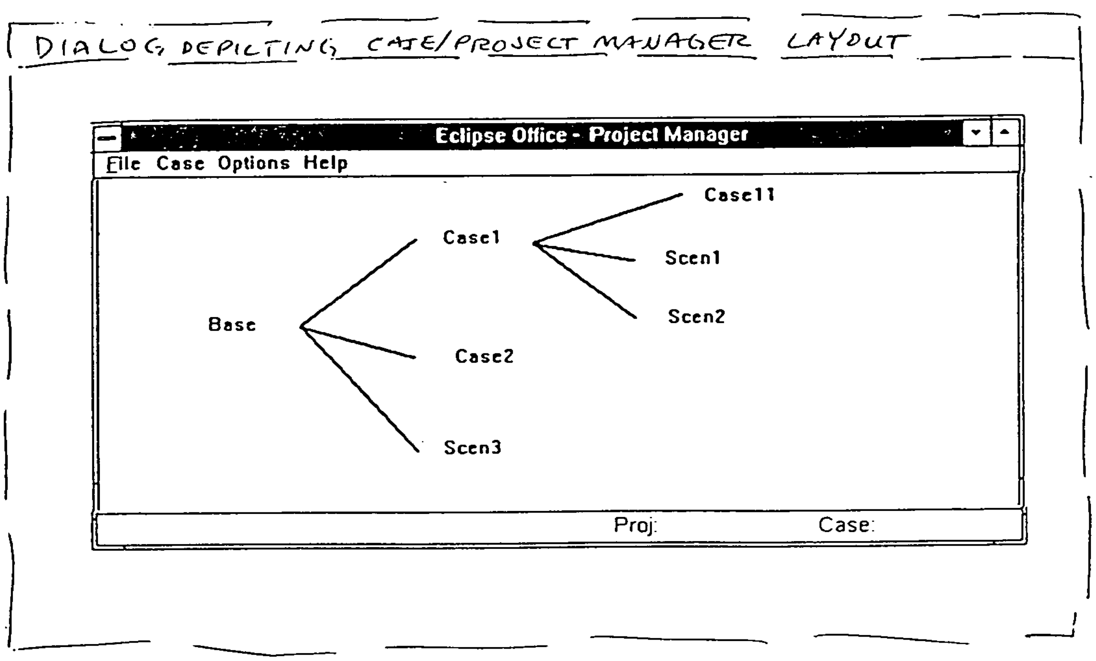
DIALOG DEPICTING CASE/PROJECT MANAGER LAYOUT
Eclipse Office - Project Manager
File Case Options Help
Case11
Case1
Scen1
Scen2
Base
Case2
Scen3
Proj:
Case:

FIG 19

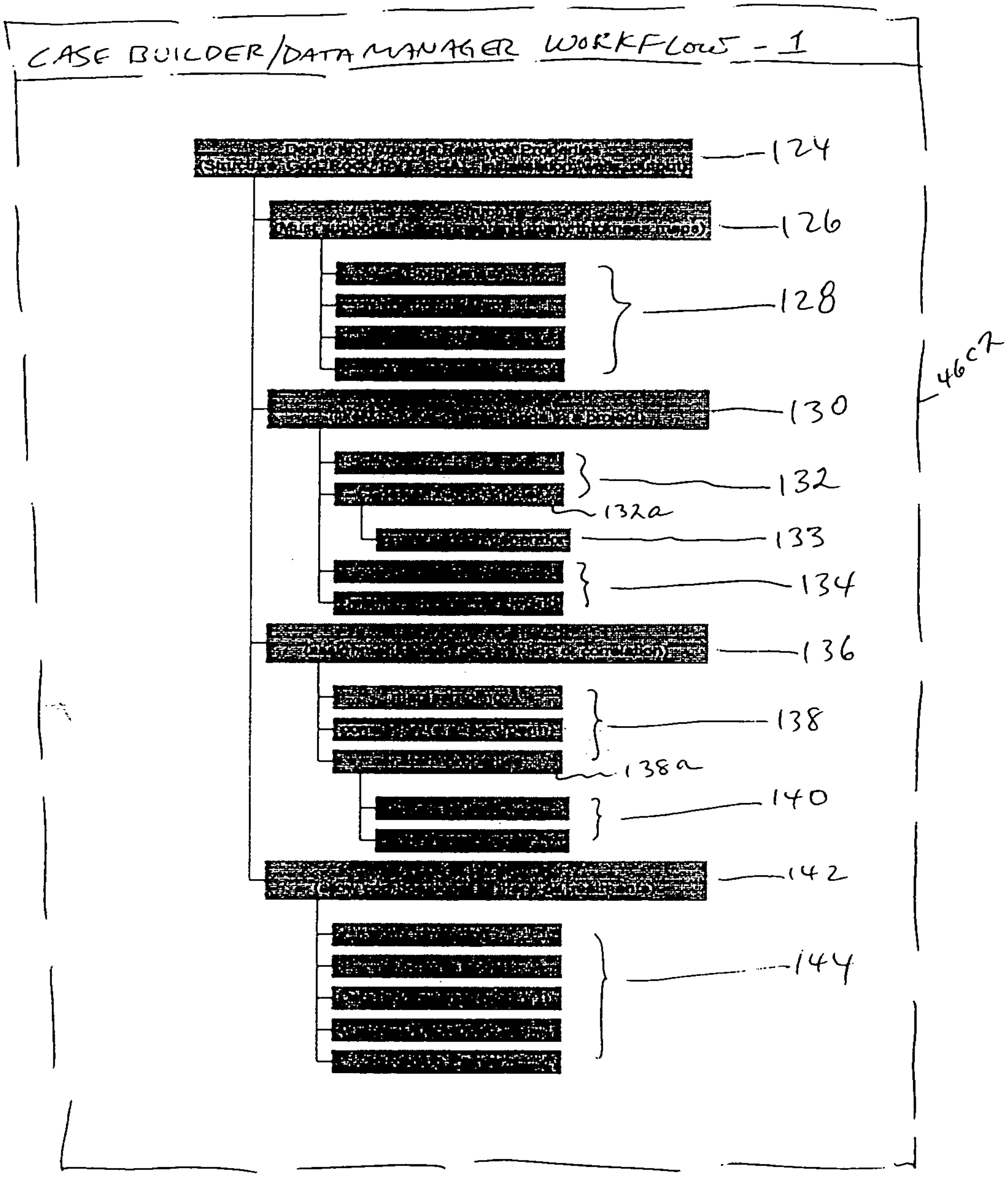
CASE BUILDER/DATA MANAGER WORKFLOW - 1
124
126
128
46c2
130
132
132a
133
134
136
138
138a
140
142
144

FIG 20a

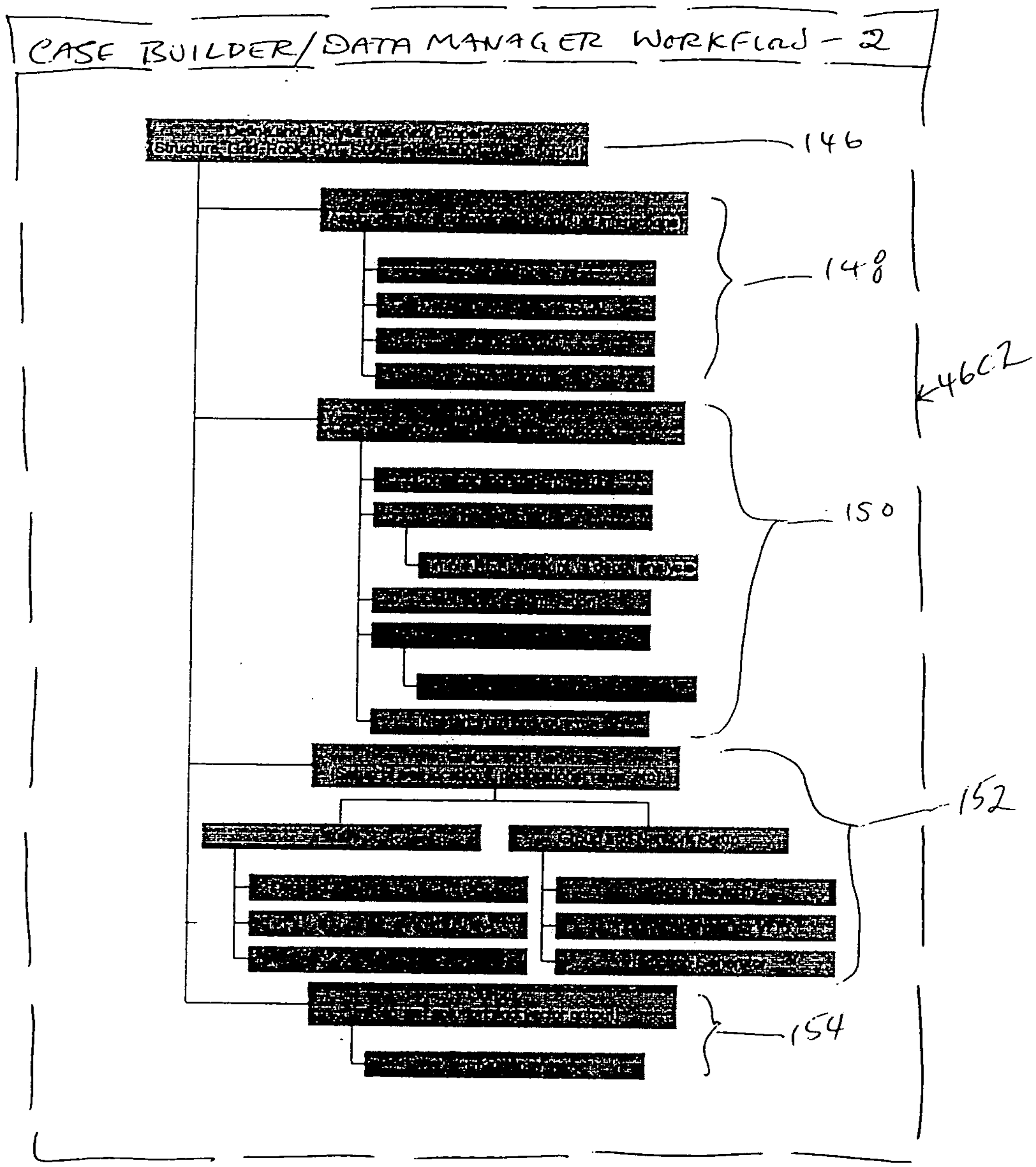
CASE BUILDER/DATA MANAGER WORKFLOW - 2
146
148
46C.2
150
152
154

FIG 20b

DIALOG DEPICTING CASE BUILDER/DATA MANAGER LAYOUT

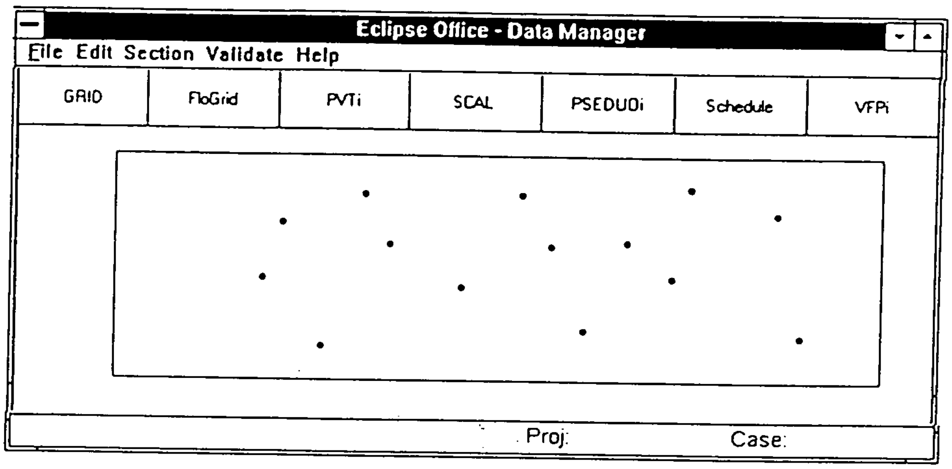

FIG 21

DIALOG DEPICTING RESERVOIR DESCRIPTION LAYOUT

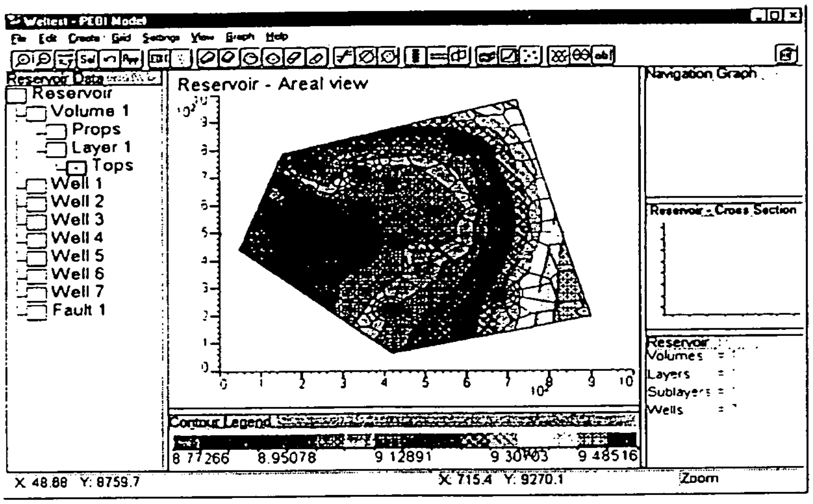

FIG 22

DIALOG DEPICTING PVT LAYOUT

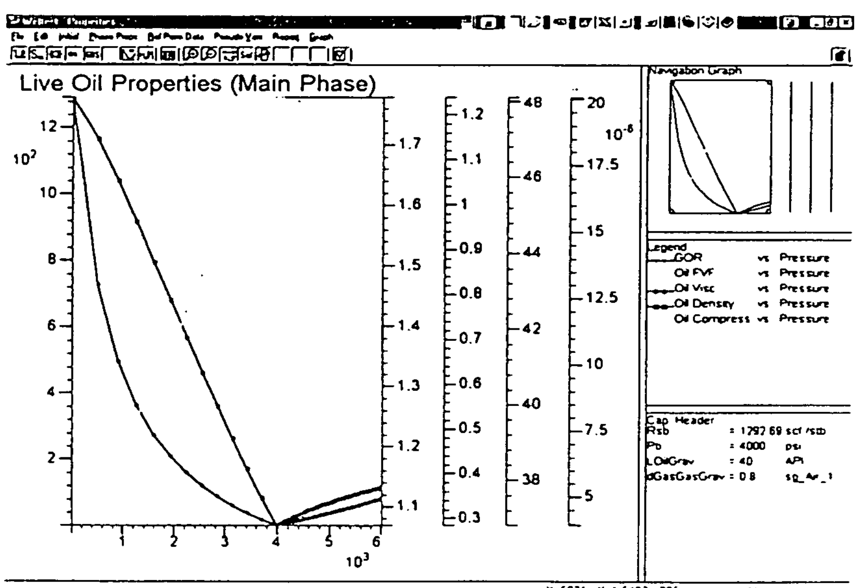

FIG 23

DIALOG DEPICTING SCAL LAYOUT

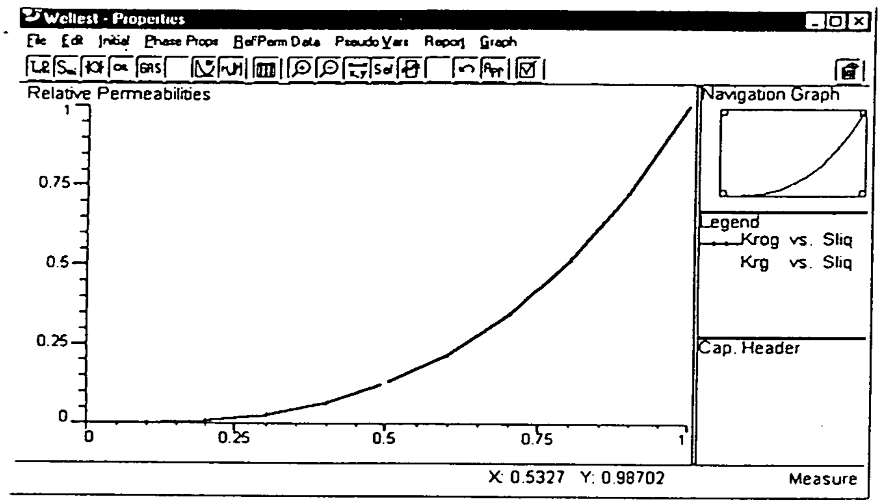

FIG 24

DIALOG DEPICTING SCHEDULE LAYOUT

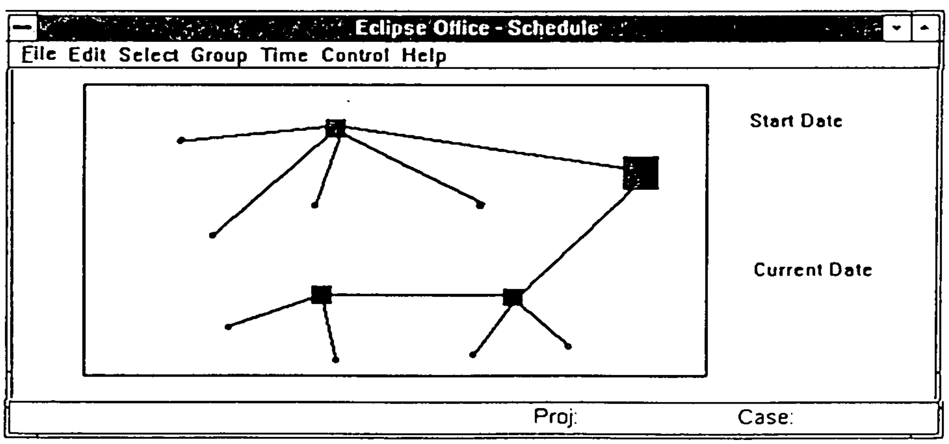

FIG 25

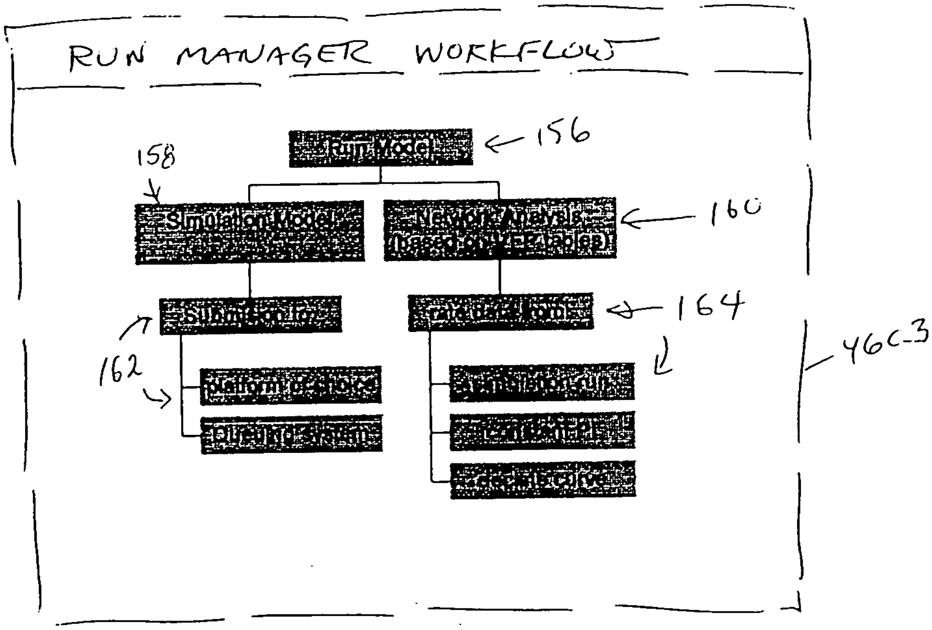
RUN MANAGER WORKFLOW
Run Model
156
158
Simulation Model
160
162
164
46C-3

FIG 26

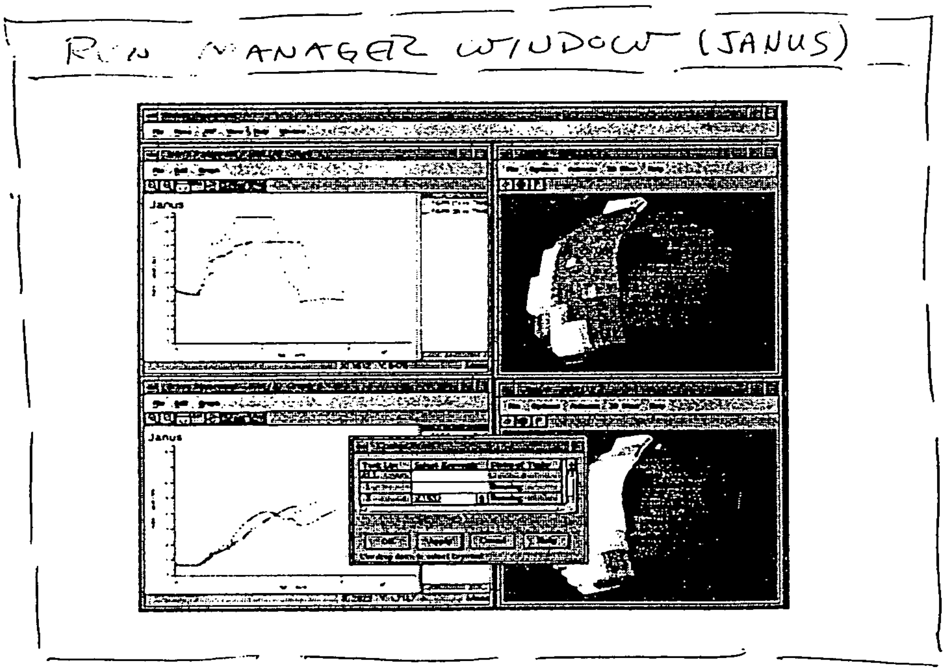
RUN MANAGER WINDOW (JANUS)
Janus
Janus

Fig 27

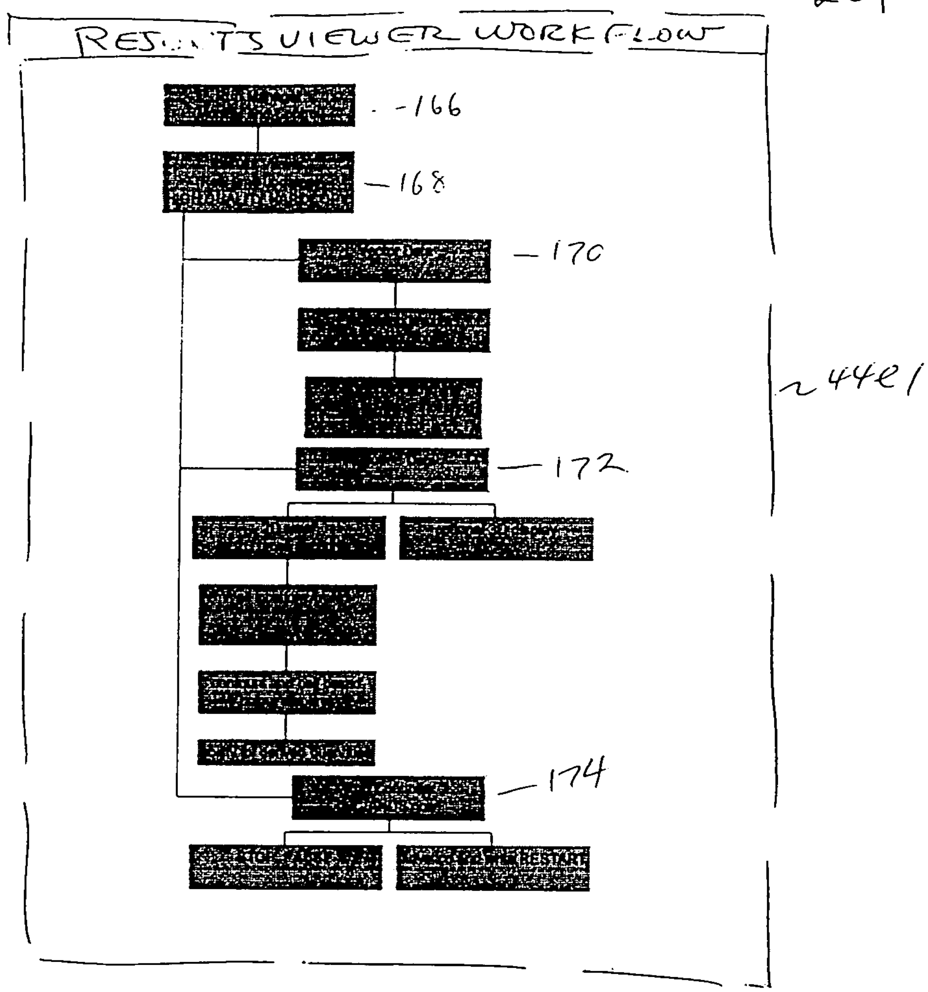
RESULTS VIEWER WORKFLOW
166
168
170
172
174
44e1

Fig 28

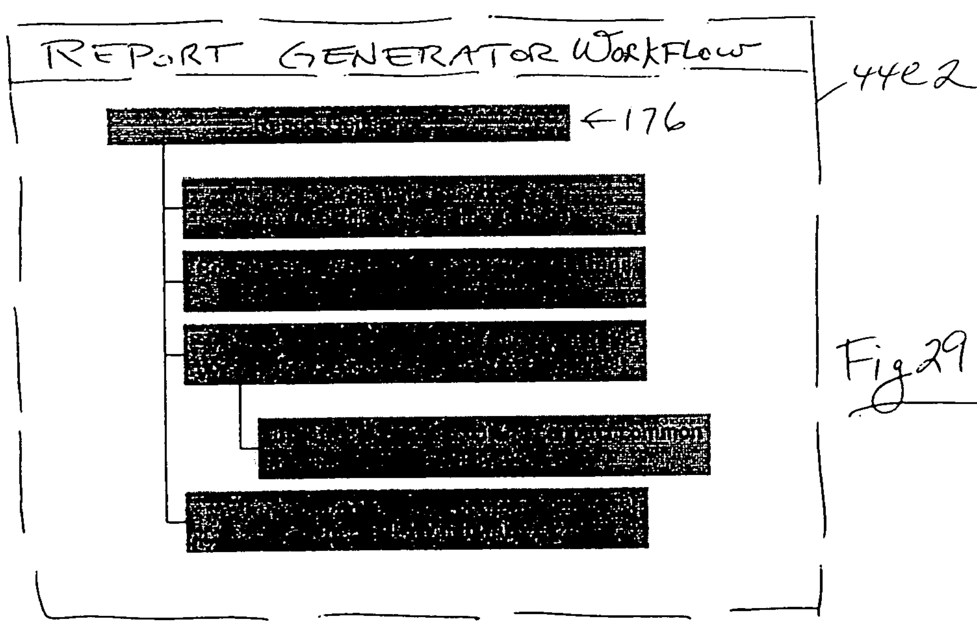
REPORT GENERATOR WORKFLOW
176
44e2

Fig 29